CHAPTER V. THE FEDERAL PROGRAM

OVERVIEW

The principal barriers to commercialization of geothermal energy are uncertainty about reservoir performance during extended production; the lack of economic technologies for all but the highest quality resources; the ambiguous status of ownership of geothermal fluids; the slow pace of current leasing; permitting, and licensing procedures; the site-specific acceptability of waste fluid disposal and other environmental control measures; and user inexperience with the resource. Divided among various agencies and offices, the Federal geothermal program works, whenever possible, in close communication with energy companies and other potential users of the geothermal resource. This chapter describes these and other aspects specifically, but does not consistently identify the agencies responsible for program execution. The reader is referred to Table IV.4, which describes these missions.

A. COMMERCIALIZATION

The hydrothermal commercialization program of DOE seeks to accelerate commercial utilization of hydrothermal resources for electric power and for direct heat applications, thereby displacing fossil fuels. This program formulates geothermal commercial development plans, develops a national progress monitoring system, assesses the market penetration potential for hydrothermal resources, and identifies direct heat markets suitable for early penetration. Further activities encompass development planning in cooperation with local and state officials and potential users, support for economic and engineering feasibility studies, continuing interagency coordination and policy development, and outreach programs to acquaint potential users with the availability and competitive cost of hydrothermal energy and with the availability of financial assistance through various Federal programs. The program also seeks to make States a principal partner in implementing the Federal program by funding State commercialization and planning teams.

Outreach

Except for a small group of technical specialists, few people understand the range of possible applications of geothermal energy. DOE/RA now has a pilot-level outreach program, which by FY 81 will become a full-scale, aggressive program. One phase aims to inform potential users and developers and their support groups of geothermal energy's costs, benefits, safety, reliability, and environmental effects. A second phase reaches out to the general public, trade, industrial, and professional associations, and other large groups capable of making primary financial commitments to geothermal development.

By lending financial and technical assistance to a few projects, the Federal government hopes that use of geothermal energy will spread. For example, Federal funds are helping the city of Klamath Falls (Ore.) to design and build an extensive geothermal space heating system, which

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initially will serve more than 100 private commercial buildings. Other cities are following suit: in Boise (Ida.), city officials, community leaders, and residential developers are doing detailed planning for a district heating system. In Marlin (Tex.), the Torbett-Hutchings-Smith Memorial Hospital will soon have geothermal heat, and a ranch near Rapid City (S.D.) is already geothermally heating its ranch buildings as well as drying grain and providing warm water for its stock. Nine district heating systems are now being funded and seven other projects may be expanded into district heating systems.

DOE is working closely with the paper pulp and food processing industries in their investigations into the feasibility of geothermal energy use. As these studies continue, the subtleties of energy use within an industry are revealed. A paper pulp industry project now in progress is concentrating on three areas: surveying the techniques used in industry to make capital investment decisions; developing the technical and economic evaluation methodology; and collecting data from pulp and paper plants.

The outreach program seeks to gain commitments for prospective development from business and community leaders. This involves working with trade associations and professional societies, and helping communities find other forms of Federal assistance to enhance their own investments. Such brokering activity is increasing, and public and private entities other than DOE are becoming interested in funding geothermal experiments.

Direct Heat Applications

The principal goal of the direct heat applications program in DOE is to build a direct-use infrastructure by funding selected direct heat applications. The most visible success of the program is in Klamath Falls (Ore.), where DOE funding, combined with city, county and state funding, enabled most of the initial stages of a project to heat the city's downtown area geothermally. DOE funds were used for well drilling, pipelines, and software design. Two production wells have been drilled and pipeline is now being procured. The design stage has begun. In early 1981, the system will go into effect, heating 14 Federal buildings in downtown Klamath Falls. After one year, DOE funding and management will cease. Although the project has not yet sought commercial sponsors, a survey of the city's business community revealed overwhelming support for the concept. Project sponsors estimate that 115 buildings could tap into the grid in the near term. The city has recently applied to the Department of Housing and Urban Development for a Community Development Block Grant to extend the system to its economically depressed areas.

Direct heat applications are divided into four groups: industrial applications, district heating, space heating, and agricultural uses. Each project goes through five phases: an environmental report, reservoir confirmation, system design, construction and installation or retrofit, and operation.

The first solicitation for direct use field experiments was issued in 1977; 22 proposals were received. Eight of these proposals were selected for contracts, with the Federal share of the cost varying from 46 percent to 80 percent. A total of $2.1 million was obligated in FY 78 for the initial phases of these projects, resulting in commitments of $2.9 million in FY 79 and $650,000 in FY 80 to complete these projects.

A second solicitation was issued in FY 78, resulting in 40 proposals, of which 15 were selected for initial FY 79 funding of $4.9 million. Approximately $10 million in FY 80 and $5 million in FY 81 will be required to continue these projects. Federal cost-sharing amounts to about 60 percent of total project costs.

Of the 23 contracts underway in FY 79, the majority are for space and district heating, while three are directed at agriculture, and three involve industrial processing. Table V.1 presents the potential energy of these projects--the equivalent of 900,000 barrels of oil per year would be displaced.

First Solicitation Projects

(1) Space Heating--Torbett-Hutchings-Smith Memorial Hospital, Marlin, Tex. This project will augment space and water heating. Geothermal fluids will be pumped from a known hot water reservoir, using a new well to be drilled as part of this project. The well has been drilled and tested, and design is under way. The project will operate in the fourth quarter of 1980.

(2) Space Heating--Phillips Schools, Haakon, S.D. Schools will be heated with geothermal water from a well to be drilled into the Madison aquifer. The government is sharing costs for design, construction, and start of operations for the complete system. The well has been drilled and the system designed. The system will be operational in the second half of 1980.

(3) Space Heating--St. Mary's Hospital, Pierre, S.D. The heating system will be augmented with a system drawing hot water from the Madison aquifer. Extension of the system to a nearby commercial complex is anticipated. The well has been drilled and the system is being designed. The system will be operational in the second half of 1980.

(4) Agricultural Use--Rapid City, S.D. A low-temperature geothermal resource will be used to supply heat to ranch buildings and will also be used to dry grain and to provide warm stock water for ranch use. The reservoir has been confirmed, the system designed, and construction begun. The system will be operational in the first quarter of 1980.

(5) District Heating--Monroe, Utah. A district heating system will be built, based on the development of a known hydrothermal resource in the area. The project will provide production wells and design and construction of the system. The well has been drilled and design begun. The system will be operational in the fourth quarter of 1981.

(6) Industrial Use--Ore-Ida Foods, Ontario, Ore. Ore-Ida planned to use a geothermal energy resource to retrofit a fossil fuel system for food processing and space heating in its potato processing plant. A well was drilled to significant depth in preparation for testing the reservoir. However, insufficient water was found and the project was abandoned.

(7) District Heating--Klamath Falls, Ore. This project will entail design and construction of an extensive geothermal space heating

Table V.1

POTENTIAL ENERGY PRODUCED BY FIELD DEMONSTRATION PROJECTS

	$\times 10^9$ Btu/yr
District Heating	
Klamath Falls, Ore.	300
Susanville, Cal.	41
Boise, Ida.	2070
El Centro, Cal.	2
Elko, Nev.	38
Monroe City, Utah	32
Reno, Nev.	18
Madison County, Ida.[1]	680
Pagosa Springs, Colo.	32
Institutional	
THS Hospital, Tex.	11
Navarro College, Tex.	35
Utah State Prison, Utah	11
Montana State Hospital, Mont.	69
St. Mary's Hospital, S.Dak.	19
Haakon School, S.Dak.	5
Klamath Falls YMCA, Ore.	5
Agribusiness/Agriculture	
Utah Roses, Utah	75
Kelly Hot Springs, Cal.	24
Aquafarms, Cal.	17
Circle Ranch, S.Dak.	36
Industrial	
Ore-Ida, Ida.	335
Holly Sugar, Cal.	1300

[1] Includes potato processing plant.

system in the central business district of Klamath Falls. As a city-owned-and-operated system, initially it will serve 14 office buildings, but will expand to 115 private commercial buildings. The system will initially include one production well, one reinjection well, approximately 2 miles of transmission line, retrofitting equipment for all 14 government buildings, and control equipment. The reservoir has been confirmed and the system designed. The system will operate in early 1981. The city has applied for a Community Development Block Grant from HUD, to extend the system to economically depressed areas.

Second Solicitation Projects

(1) Heating—Utah State Prison, Salt Lake City, Utah. Using the Crystal Hot Springs, one building of the Utah State Prison will be heated with geothermal fluids. This demonstration will form the nucleus of a system that can be expanded to service the heating requirements of other existing and planned facilities. The contract was negotiated in June 1979; negotiations are now being conducted for land for the well site. The project will operate in mid-1981.

(2) Multiple Uses—Madison County, Ida. A joint venture by Madison County, Idaho, and Rogers Food, Inc., for this project will develop geothermal energy for municipal space heating and industrial food processing. The contract was negotiated in June 1979. Reservoir confirmation studies were begun, and the system will operate in the fourth quarter of 1981.

(3) Multiple Uses—Moana, Reno, Nev. An apartment complex will be retrofitted with a geothermal space and water heating system using thermal waters in the Moana District, a known geothermal resource. The contract was awarded in June; reservoir confirmation studies are under way. The system will operate the first quarter of 1981.

(4) District Heating—Pagosa Springs, Colo. An extensive geothermal heating system will be developed within the town of Pagosa Springs. Designed to permit expansion of other businesses and homes beyond the town limits, this system provides hot water for space heating to 12 public buildings and schools, 25 private buildings, and several homes. The well is being tested in preparation for system design. The system will operate the third quarter of 1981.

(5) Direct Uses—Elko, Nev. Under the ownership of a heat source company, geothermal fluid from the Elko KGRA will provide space, service water, and process heating to several buildings within the city. The contract was awarded in July 1979, and reservoir confirmation studies have been completed. The system will operate the first quarter of 1982.

(6) Direct Use—Salt Lake City, Utah. Six acres of floral greenhouses will be converted from oil and gas heating to a geothermal system. The contract was awarded in April 1979. Reservoir confirmation has been completed in preparation for drilling. The system will operate in the third quarter of 1980.

(7) District Heating--Boise, Ida. The city of Boise and the Boise Warm Springs Water District will develop a large-scale space heating system using geothermal energy to demonstrate the technical, economic, and organizational feasibility of using low-temperature fluids in a multijurisdictional endeavor. The DOE contract was awarded in June 1979; participants are arranging additional financing. The system will operate the third quarter of 1983. An additional $500,000 was provided by the Economic Development Administration.

(8) Space Heating--Warm Springs Hospital, Butte, Mont. Utilities at a hospital will be partially converted to use geothermal energy instead of natural gas. The project continues state-funded studies to determine the feasibility of converting to a geothermal resource, and to more fully define the resource on hospital property. It will involve drilling of wells and design of the modification of the hospital's hot water and space heating system. The contract was awarded in March 1979. Reservoir confirmation is now taking place. The system will operate the second quarter of 1981.

(9) Space Heating--Navarro College, Corsicana, Tex. Using a known resource, the contractor will retrofit two buildings: the college student union and the Navarro County Memorial Hospital, to augment the existing space and water heating requirements. The contract was awarded in January 1979. One well is being tested, in preparation for drilling another well. The system will operate the third quarter of 1981.

(10) Agricultural Uses--Kelley Hot Springs, Cal. Using two wells, the Geothermal Power Corporation will demonstrate geothermal direct applications to a livestock feed production system and hog feed lot operation. The contract was awarded in June 1979, and well testing was begun. The system will operate the second quarter of 1982.

(11) District Heating--Susanville, Cal. The city will use Susanville's geothermal resource to heat 17 existing public buildings. A parallel effort will expand the city system and develop a commercial park. The contract was awarded June 1979. Well drilling is in the preparation. The system will operate the first quarter of 1982.

(12) Agricultural Use--Aquafarm Prawn Raising, Mecca, Cal. A commercial fish farmer will expand an existing geothermal supplied system to raise giant Malaysian prawns. The contract was awarded in mid-1979. Reservoir studies have been conducted. The system will operate the fourth quarter of 1980.

(13) Space and Water Heating--YMCA, Klamath Falls, Ore. Geothermal fluids from a recently drilled well will provide space heating and hot water for the YMCA building. The existing fossil fuel system will remain as a backup or booster system. The contract was awarded in April 1979. The well, previously drilled, was completed and tested. The system will operate the second quarter of 1980.

(14) Industrial Use--Holly Sugar Geothermal Project, Brawley, Cal. This project involved the design, installation, and operation of a geothermal energy system to be used directly for process heat. The contract was awarded in April 1979. Reservoir confirmation studies were

done in preparation for drilling. The system will operate the first quarter of 1982.

(15) Space Heating and Cooling--Geothermal Core Field Experiment, El Centro, Cal. Heber's geothermal resources will provide space cooling and heating, and domestic hot water to the community center at El Centro. This project is intended to serve as the core for a future district heating and cooling system for the city. The contract was awarded in April 1979, and preparations made to drill the well. The system will operate the second quarter of 1981.

Feasibility Studies

This program funds studies to determine the technical and economic feasibility of proposed hydrothermal applications. These are done in conjunction with potential users. Feasibility studies fall into one of three categories: industrial processing (food processing, sugar production, fertilizer production, mineral processing and other studies); district heating (heating systems for communities by public or private utilities and for smaller users); and agribusiness and aquaculture (production and processing of food at the farm).

DOE is currently funding 11 feasibility studies of direct application, including process heat for frozen food production, process heat for corn sweetener production, process heat for methanol and ethanol from farm products, process heat for hosiery production, process heat for tungsten mining and processing, and district heat for other applications. These studies were chosen from among 77 proposals received in response to the Engineering and Economic Feasibility solicitation made early in FY 79. The large number of responses is extremely encouraging.

Since the geothermal program began, 23 such studies have been completed--7 of space and district heating, 10 of industrial processing, and 6 of agribusiness or aquaculture. Results from 17 completed studies were analyzed for factors influencing decisions to invest in direct use processes. The cost of energy from geothermal sources was shown to be competitive with fuel-oil-based energy if at least 20 percent of the energy from the wells is used. A typical application would meet this qualification. Eight of these studies comprised 20 separate applications: food processing (12), space heating (4), crop drying (3), and a long-distance pipeline (1). All the resources studied were located in the western United States, in particular in California, Oregon, and Colorado.

The Forest Service, in conjunction with DOE, the California Department of Water Resources, and Geoproducts, Inc., is looking at the feasibility of using geothermal energy and wood chips from forest waste at Honey Lake to produce electric power. Lands in Toiyabe, Inyo, and Lassen National Forests will be evaluated for possible geothermal development.

In FY 79 the following studies were completed:

- A district heating and cooling system for El Centro, California, now part of the specific application program.

- A combined direct thermal and augmented district heating system for Susanville, California, also now part of the specific application program.

- A large resort complex in the San Luis Valley, Colorado, combining agriculture and space heating. The final report is expected in FY 1980.

- A school complex in Edgemont, South Dakota, exploring feasible use of the Madison Aquifer water.

- A vertically integrated meat and feed production facility for Mountain Home, Idaho. This study was moved to a different site, then incorporated into the specific application program at Kelley Hot Springs, California.

- A study of cane sugar production in Hawaii, showing the system to be technically feasible but only marginally profitable if based on private financing.

B. FEDERAL USE OF GEOTHERMAL ENERGY

The Department of Defense is under the same mandates as the rest of the Federal sector to conserve energy and switch to alternate fuels. The direct use of geothermal energy as well as the use of geothermally generated electricity are significant factors in achieving the mandated goals.

Several direct use projects are either in the planning or initiation stage and one at the Naval Station, Keflavik, Iceland, is about to be constructed. There the entire Navy base will be converted to geothermal heating.

At NWC China Lake, Coso, California, the Navy is using a private entrepreneur to explore the resource, develop the field, construct an electric power plant, and operate it at no cost to the Navy. The Navy has agreed to buy all power produced from the plant. Through this effort a previously untapped resource will be used and, if successful, should attract more developers to the remainder of the Coso resource when it is offered for development.

DOE is attempting to help other agencies identify buildings and facilities that could use geothermal energy for heating and cooling. Primary emphasis has been on DOD, but contacts have also been established with the U.S. Postal Service and other Federal agencies.

Adak Naval Station, Adak, Alaska

The Adak Geothermal Project is considering three different types of geothermal energy systems, each based on an assumed reservoir temperature range:

- Space heating, using either above-ground insulated fiberglass pipelines or in-ground insulated steel pipelines.

- Flash steam electrical power generation, using geothermal fluids either at a central power plant or via individual wellhead generating units, either system producing a 25 MWe gross output

- A binary geothermal electrical power plant, where the geothermal fluids would heat a secondary (binary) fluid to operate the electrical generating equipment, producing a 25 MWe gross output.

Of the systems analyzed, the most attractive are the wellhead generating units, which have been tested at ambient temperatures ranges as low as 160°C. Equipment can be fabricated in the lower 48 states, thus eliminating much of the cost of installation and construction at Adak. A wellhead unit system has the best payback period of all the systems and could be operational within 5 years from the date the reservoir is defined.

The primary question remaining is which system can the geothermal resource of Adak support? This question can only be answered by drilling the initial production-size wells to test the reservoir characteristics. The estimated cost for drilling the first production hole at Adak is $8.5 million, due to the high cost of drilling rig mobilization. This high cost makes the whole project unattractive until fuel costs increase significantly. If that increase occurs, the project will be reevaluated.

China Lake Naval Weapons Center (NWC), Coso, California

Based on geological surveys by the USGS, China Lake personnel, and others, the Coso area of China Lake NWC was designated a known geothermal resource area (KGRA) with an estimated resource potential ranging up to 4,600 MWe. About 90 percent of the high-grade resource lies within NWC boundaries; however, some of the area is fee-owned lands. The Navy has two objectives--to protect its military mission capability, and to develop the resource. Accordingly, the decision has been made that the Navy will develop fee-owned lands for its own use while allowing the Bureau of Land Management to lease the remainder of the resource, subject to appropriate constraints. The Navy proposes to hire a private contractor to further explore, develop the field, build a power plant, and own and operate it at the contractor's expense. Under this plan, the Navy will retain ownership of the resource and the electricity generated by the resource. The contractor will be paid for the electricity produced. The Navy filed a draft environmental impact statement for this undertaking in November 1978 and has completed the contractual package.

Initially, the minimum amount of power the Navy will accept will be the entire requirement of the Weapons Center. After this requirement has been satisfied, the contractor may pick up additional loads, up to a maximum of 75 MW. Development beyond 75 MW will be at the option of the Navy.

Technical proposals for this project have been evaluated and at this printing the Navy is asking for pricing. A contract should be awarded by the end of FY 79.

Fallon Naval Air Station, Fallon, Nevada

For Fallon, USGS studies give a reasonable assurance of a good geothermal resource potential; indeed, some geothermal applications have already been implemented in the immediate area of this base.

The Navy is now conducting heat flow studies to determine the extent of the resource on U.S. lands. In FY 80 the resource analysis will be completed. Current indications are that a geothermal project is definitely feasible and that geothermal electric power production is likely. If a substantial resource is proven, the Navy can produce excess power and wheel it to other DOD locations.

Hill Air Force Base, Utah

In a joint project between the Department of Energy and the Department of Defense, the availability of geothermal resources at Hill AFB will be developed. In addition to evaluating Hill's geothermal energy potential, this effort will broaden the scientific knowledge about reliable techniques for detecting hot water sources in faults along the populous Wasatch Front.

The project is divided into two phases. Phase I will identify and initiate use of the geothermal resource. Phase II, predicated on the success of Phase I, would expand the application to other areas of the Base. In Phase I, DOE will take responsibility for surface exploration and geological interpretations, followed by exploratory production and, if necessary, reinjection well drilling. DOD will design and construct the distribution system and modify the facility heating, if necessary, and will prepare a system performance report. Phase II will be entirely the responsibility of DOD.

Two holes are being drilled to test geologic structures, one to a depth of about 2,000 feet and the other about 3,000 feet. The scientific team from the University of Utah that performed the initial geological, geochemical, and geophysical studies at the Base is also managing the test hole drilling. Interpretation of the results from these test hole wells is scheduled for early FY 80. Phase I development is estimated to last 36 months.

Keflavik Naval Station, Iceland

Geothermal resources have been used to heat Iceland's capital city, Reykjavik, for 50 years. The United States is committed by a 1974 Memorandum of Understanding to join with the Icelanders in developing geothermal heat sources.

Sudurnes Regional Heating Corporation (SRHC), a local entity, is developing geothermal wells and distribution lines to towns near Keflavik. Distribution lines now connect the Svartsengi plant area with towns on the

Reykjanes peninsula; connection of Icelandic buildings is well advanced. However, the hookup of U.S. facilities of geothermal heat has been minor to date.

In FY 80, a military construction project will start conversion to geothermal energy by providing connection charges to SRHC. Most of the conversions of Navy boiler rooms and heating systems will be programmed next year. However, should installation of heating mains proceed at a pace permitting usable connections to some Navy buildings in FY 80, a portion of this project will be assigned to initial conversion work, now planned for FY 81. The total budget for connection and conversion is $35 million.

Norfolk Naval Station, Norfolk, Virginia

The demand potential for geothermal space heating at Norfolk appears to be excellent. However, before wells to define the resource are drilled, resource criteria must be established. The Navy is currently developing a program to identify the potential heating load at the Norfolk Naval Station--its location, resource temperature requirements, and flow requirements. In addition, site-specific legal, institutional, and environmental problems must be resolved. The Navy will then proceed with development if the project is still feasible.

Williams Air Force Base, Arizona

In 1973, a private firm drilled two geothermal wells to a depth of 10,000 feet, approximately 1 mile from Williams. These wells demonstrated a hydrothermal resource of around 150°C. In June 1979, the Department of Energy completed a feasibility study for the Air Force, exploring the potential applications of geothermal energy at Williams.

The study concluded that both a central cooling plant and an electrical power plant are promising candidates for geothermal use; the choice will depend on the quantity and quality of the resource. The economic analysis projected a potential payback period of 11-15 years.

The Air Force has prepared a conceptual plan that divides the project into two development phases. Phase I encompasses exploratory production well drilling, and Phase II, follow-up drilling and design and construction of the central plant. Management and financial arrangements to accomplish these phases are being developed.

C. INTERNATIONAL ACTIVITIES

The pace of commercialization of geothermal energy in the United States is affected by the status of geothermal development in foreign countries. Some countries can supply technologies and materials to U.S. developers, while other countries are supplied by U.S. manufacturers. In this latter case, U.S. manufacturers can achieve a scale of production sufficient to stay in business, while also supporting the national commitment to help those countries develop their own energy resources.

Table V.2

WORLDWIDE GEOTHERMAL ELECTRICITY GENERATION
(to 1984)

Country	Present Capacity (MWe)	Planned Expansion (MWe)
China	4.5	--
El Salvador	60.0	385.0
Iceland	64.0	--
Indonesia	0.3	--
Italy	420.6	400.0
Japan	168.0	250.0
Kenya	--	35.0
Mexico	153.0	140.0
New Zealand	202.6	150.0
Philippines	224.2	1105.0
Taiwan	0.3	--
Turkey	0.5	14.0
USSR	5.0	58.0
United States	674.0	1401.0
TOTAL	1977.0	3938.0

Based on information gained from such international activities, Federal commercialization strategy and program plans are adjusted to reflect needs peculiar to U.S. manufacturers trading abroad.

At present, worldwide installed capacity is 1977 MWe, with planned additions of 3938 MWe (see Table V.2).

At least 20 other countries have active geothermal energy programs, and through multilateral and bilateral agreements the United States participates in international programs. Generally, the agreements call for the exchange of information, exchange visits of scientists, and selection of areas for cooperative activities. In some cases, agreements have led to more active cooperative research and development programs.

Multilateral Programs

A 15-month study called "Man-Made Geothermal Energy Systems" (MAGES) is being conducted by the International Energy Agency (IEA). Six of the nineteen IEA participants (the United States, the Federal Republic of Germany, Sweden, Switzerland, Japan, and the United Kingdom) are active in MAGES, which explores hot dry rock systems and equipment. In FY 79, the first phase was successfully completed. As a result, under a new bilateral agreement between the United States and the Federal Republic of Germany, German scientists will participate in the Los Alamos Scientific Laboratory's (LASL) hot dry rock project, and will contribute about $2.5 million per year.

In FY 79, the United States, Mexico, New Zealand, and Italy signed a cooperative agreement, under the auspices of the IEA, to test a U.S.-produced wellhead generator unit, the helical screw expander that was successfully operated at Roosevelt Hot Springs, Utah, in FY 79.

Bilateral Agreements

Formal bilateral agreements exist between the United States and Italy, Mexico, Germany, El Salvador, Taiwan, New Zealand, Egypt, Peru, and Japan.

U.S.-Italy. There are two separate geothermal agreements with Italy. The first involves reservoir stimulation and computer modeling, environmental control technology, and seismic studies. The second provides for continued data exchange through computerized information systems.

In FY 79, well selection for hydrothermal field stimulation tests was completed, following information exchange and site visits. Data collection and evaluation for reservoir modeling at Larderello, Radicondoli, and Bagnore are on schedule. Collaboration in environmental research is proceeding as planned, and H_2S will be monitored after an air quality and meteorological monitoring network for the Larderello field is established. Information was exchanged on materials and geochemistry, deep drilling problems, drill muds, and high-temperature cements. The United States provided monitoring equipment for radon and H_2S emissions. In addition, seismic instrumentation was installed in Torre Alfina, Latera, and Cesano.

U.S.-Mexico. The U.S.-Mexico bilateral geothermal agreement has produced a cooperative program to collect and analyze field data for reservoir engineering studies. In FY 79, cooperative investigations on the geophysical and hydrological characteristics of the Cerro Prieto field continued. Proceedings of the First Symposium on the Cerro Prieto Field (held in 1978) were published. A dynamic model of the field is being developed and should aid in understanding the field interactions with regional aquifers, particularly as affected by reinjection of geothermal fluids. Discussions are under way to extend these cooperative efforts to other geothermal fields.

U.S.-Japan. An implementing agreement between DOE and the Agency for Industrial Science and Technology of Japan, signed in FY 78, provides for development and evaluation of the geothermal resource data base, new techniques for resource assessment, drilling and fracturing volcanic studies, transportation of steam and hot water for direct use, evaluation of reservoir life, and environmental studies. The first executive coordinating committee meeting was held in May 1979. Both countries presented information about their domestic programs and discussed possible cooperative projects. Japan expressed an interest in exchanging information on binary conversion systems and in participating in the LASL hot dry rock project. A geothermal technology exchange project is currently being negotiated with the Japanese government.

U.S.-New Zealand. A draft geothermal agreement between the United States and New Zealand is being negotiated. Areas of cooperative study will include drilling and completion, instrumentation, chemistry and materials, stimulation, reservoir engineering, two-phase flow, and brine disposal.

Other bilateral agreements provide for information exchange, resource assessment support, cooperative economic analyses, and exchange visits between the United States and El Salvador, Taiwan, New Zealand, Egypt, and Peru. Continuing participation by the United States in the IEA activities, in possible future NATO-CCMC cooperative studies, and in other international meetings is expected to lead to additional bilateral agreements.

Other International Activities. Many nations are assigning increasingly greater priority to the development of indigenous energy sources, including geothermal energy. The growth of these potential markets is generating some export competition among countries with developed geothermal technology.

The early phase of development has commonly been financed by grants from the United Nations Development Program. Financing for the later phases of development has been provided by international development financing institutions such as the International Bank for Reconstruction and Development and the Inter-American Development Bank, sometimes in combination with vendor financing supplied by major equipment manufacturers.

The U.S. geothermal industry has, historically, concentrated on domestic markets. Geothermal technology has been exported primarily because large energy corporations or architectural and engineering firms

have used existing sales networks or foreign contacts. Now other U.S. companies are awakening to the potential for export of geothermal expertise, especially in less developed countries (LDCs), but little information is available about the base and potential size of foreign markets.

During exploration and feasibility studies, U.S. drilling companies have enjoyed leadership, and geophysical and geological firms are competitive with those from other countries. During field development and production, established firms with local contacts often have a significant economic advantage over firms that must bring in operating equipment and personnel. During design and construction of the power plant, American architectural and engineering firms are at a disadvantage because they cannot finance equipment quickly enough to be competitive with other countries that export geothermal technology, particularly Japan, Italy, New Zealand, or France; these countries benefit from a tradition of close government-business cooperation.

It is unclear whether a Federal geothermal technology export policy would assure U.S. firms a role in the growing international market. To determine the answer, data on potential geothermal markets must be aggregated. A review of existing cooperative agreements may point the way to opportunities for international marketing.

During FY 79, DOE sponsored a number of studies:

- To define the potential commercial market for U.S. industry in foreign countries
- To investigate policy options and implications for the United States in such markets, particularly the costs and benefits that export expansion would have for domestic commercialization
- To determine the conditions under which the American geothermal industry would be interested in participating in foreign geothermal development
- To assess receptivity of LDCs to marketing of U.S. technology
- To define the relevant legal, institutional, social, and environmental constraints

These studies will be completed in FY 80. Preliminary findings indicate that many large U.S. energy companies prefer overseas geothermal projects because power plants can be developed more quickly than in the United States. However, smaller companies, without resources to sustain operations abroad, will remain focused on the U.S. market. (Tax considerations, in particular tax treatment of overseas earnings, have a significant impact on the investment posture of energy companies.)

U.S. financial institutions are cautious toward international geothermal projects. Therefore, funds for major near-term geothermal activities must come from internal financing (e.g., a large oil company), be backed by the host country, or be fully guaranteed by some other

institution (e.g., the Overseas Private Investment Corporation). The extent and structure of geothermal investments in developing countries may be limited by the availability of foreign reserves or by ceilings on foreign borrowing imposed by the host country or by the International Monetary Fund.

The preliminary studies noted above are delineating the structure of the energy sector in less developed countries. Because energy distribution networks and capital are limited, the appropriate scale of geothermal applications is often much smaller in LDCs than in developed countries. The 50-100 MWe commercial-scale power plants of developed countries may be too large for many sites in LDCs, where wellhead generators in the 1-5 MWe range are more appropriate. Whether U.S. firms are willing to undertake the effort and expense of retooling for smaller applications will therefore be an important factor in export policy.

On the other hand, nontechnical, noneconomic benefits may flow from transfers of geothermal technology abroad, since many countries are grappling with second-generation issues relevant to geothermal commercialization in the United States. In particular, public and private sectors cooperate in areas such as the protection of fragile environments, interface of geothermal applications with conventional utility systems (such as cascading or cogeneration), geothermal steam pricing, and brokering of geothermal projects.

D. TECHNOLOGY DEVELOPMENT

Geothermal energy recovery is accomplished with technology similar to oil and gas industry technology, but geothermal temperatures and fluid characteristics, exceeding those for which oil field equipment was designed, shorten equipment lifetimes and pose safety hazards. Surface heat recovery equipment adapted to geothermal use from existing steam technology is expensive and inefficient. And environmental problems cause unique difficulties. Therefore, technology specifically tailored to geothermal conditions is needed. The objective of the geothermal technology development program is to solve these problems. The program consists of four major areas: reservoir assessment technology, well drilling and completion technology, energy extraction and conversion technology, and geochemical engineering and materials.

The purpose of reservoir assessment technology is to more accurately predict, locate, and measure reservoirs. Relying on the industry to point out key technical problems, the government carries out research in exploration technology, reservoir engineering, logging instrumentation, and log interpretation.

Reservoir engineering systematically provides data to models that predict longevity and productivity. Case histories of producing geothermal fields serve as a basis for this modeling. For example, a case history of a comprehensive set of exploration techniques deployed at Roosevelt Hot Springs, Utah, helped evaluate the various techniques (geological, geochemical, and geophysical) used in delineating the

confirmed reservoir. This case history was compiled in FY 79; case histories for other geothermal sites are in process.

A numerical model for simulating two-phased flow in geothermal wells was developed and validated by comparison with field data. The model will enable detailed evaluation of geothermal systems, estimation of reserves (from depletion analyses), estimation of effects of injection on energy recovery, and studies of the effects of gases on reservoir depletion.

A test at the Valles Caldera (New Mexico) geothermal field successfully demonstrated electronic logging tools that functioned for 18 hours at a depth of 8,000 feet (16.5 hours at 242°C and 1.5 hours at 282°C). Previously, tools could not function above 180°C. The logging program is demonstrating to industry how to upgrade the logging capability to 275°C. The program continues to provide calibration facilities for industrial equipment and to improve interpretation of geothermal rock properties from borehole logging.

The purpose of well drilling and completion technology is to reduce the cost of geothermal drilling and to improve well completion techniques. In stage one, improvements in drill bits, downhole motors, and drilling fluids will demonstrate the technology that will make a 25 percent reduction in drilling costs possible by 1983. In stage two, a new drilling system is expected to enable a 50 percent reduction in geothermal drilling costs by 1986.

In FY 79:

- A third-generation unsealed roller cone bit, designed specifically for drilling hot, hard, fractured rock was tested at The Geysers (Cal.). The new bit drilled 30 percent longer than conventional bits drilling the same formation at equivalent temperatures. Use of this new bit can save a minimum of 4 percent on total well costs.

- A field test of the downhole replaceable chain drill bit proved successful. This test confirmed the cost benefit of changing the cutting surface of the bit downhole. Commercialization is under way.

- A new technique for removing scale from pipe was demonstrated. This new de-scaling system uses cavitating jets to remove scale from geothermal power plants; it provides a nondestructive, inexpensive, fast method for cleaning heat exchanger surfaces, flash tanks, and piping.

- Plans for an advanced drilling system were formulated, based in part on advice gathered at a workshop of 50 participants from industry, universities, and the government.

The FY 80 program is expected to bring about the commercialization of the chain-drill bit, advances in the use of man-made diamond materials, and the evaluation of candidate technology for advanced drilling systems.

The purpose of energy extraction, conversion, and stimulation technology is to reduce electric generating costs, particularly for moderate-temperature geothermal fluid. Extraction and conversion technologists improve performance and reduce costs of binary heat exchangers. Stimulation technologists develop new equipment and techniques for use in high-temperature geothermal environments, to improve formation permeability.

Major program accomplishments of FY 79:

- After a successful field test in Utah, the 1 MWe helical screw expander wellhead electric generation system was refurbished and made available to the International Energy Agency for testing at geothermal fields in Mexico, Italy, and New Zealand.

- Design of an advanced gravity head binary system is complete; major components have been ordered. This system is expected to be nearly one-third more efficient than conventional binary cycles, and could markedly improve the economies of electricity generation from moderate-temperature resources.

- A 500 kWe skid-mounted binary power system was installed at East Mesa and has undergone preliminary testing. The system is designed for moderate-temperature resources, and uses direct-contact heat exchangers.

- A 100 kWe direct-contact power system was built and moved to a test site in Marysville, Arkansas. Two months of preliminary shakedown and test runs have been completed. The system is designed for low-temperature resources.

- Several months of unattended continuous operation of the 60 kWe binary plant at Raft River have provided new data on the reliability of binary system operation with low-temperature fluids.

- A well at Raft River was successfully stimulated, increasing production threefold.

- Equipment was installed to carry out the joint DOE/EPRI heat-exchanger equipment tests at the East Mesa geothermal component test facility.

- A comprehensive source book, Utilization of Geothermal Energy for Electric Power Production,

edited by Brown University, was completed and will be published in FY 80.

Numerous studies have determined that binary cycles offer the greatest potential for reducing the costs of generating electricity from the moderate-temperature geothermal resource; thus the DOE conversion technology program is heavily oriented toward binary conversion cycles. Direct-contact heat exchangers and advanced process design are areas of particular interest. The gravity head binary system is expected to yield a significantly higher utilization efficiency by improving heat transfer characteristics and reducing parasitic loads due to feed pumps. Beginning late in FY 80, hardware for the gravity head system will be tested in a special large-diameter well at East Mesa, Cal.

An active geothermal well stimulation program was started in FY 79 with the successful hydraulic fracturing of a well at Raft River, Idaho. New tools and techniques will be used in the explosive stimulation of a well at the Geysers Geothermal Field in California. Newly developed high-temperature explosives will be used in an attempt to increase fracture permeability and to increase the flow of fluids to the wellhead.

The extraction of heat from geothermal fluids requires the handling and disposal of large volumes of water. Because the chemistry of geothermal waters is to a large extent site-specific, the problems of scale control, erosion, and corrosion require a detailed design to balance technical and economic subsystems for each potential site. The purpose of geochemical engineering and materials technology, therefore, is to address the special character of geothermal fluids and their interaction with other materials.

Fluid chemistry programs develop monitoring and control instruments, fluid control technology, and economic fluid disposal procedures that reduce scaling and cost of use. Materials development programs tailor borehole and conversion equipment to geothermal use. As noted above, oil field equipment is poorly suited to geothermal use; this is primarily because materials are degraded by the high temperatures and fluid chemistry.

In FY 79, flash tanks and pipes lined with polymer concrete were tested in East Mesa's severe scaling environment. Carbonate scale did not adhere to the polymer surface, thereby offering a potential remedy to the scaling program in a portion of the brine-handling equipment at East Mesa and other geothermal fields with high carbonate content in the water.

A handbook analyzing materials available for use in geothermal electric applications has been published to aid in the design of geothermal power plants. The handbook is being enlarged to include process and space heating applications. The new edition will be available in the summer of 1980.

Materials constitute a large part of the capital costs of low-temperature process and space heating applications. Less expensive construction materials are being developed as part of a wide range of elastomers and metals for use in the geothermal environment. Specifically, new cements for completing wells and new materials for seals are also being developed.

In FY 80, geothermal materials research will concentrate on materials for localized corrosion and wear resistance, hot-hardness and fatigue-resistant bearing and drill bit applications, and pipes made of alternative materials. This research, as well as continuing programs in seal and cable materials, is essential to the reliability of downhole pumps, instrumentation, motors, and piping systems.

Geobrine Research. Begun in 1973 under the direction of the Bureau of Mines, geobrine research has been carried out in two areas: mineral recovery and construction materials.

In minerals recovery research, a process flow scheme using hydroxide bulk precipitation techniques was devised and assembly of a process development unit at Niland (Cal.) to demonstrate the technique was started. Studies showed the sensitivity of zinc recovery to pH and temperature, and lithium recovery to aging. A new study was started, using a selective sulfide process to recover lead and zinc from high-salinity geobrines.

In FY 80, tests on the bulk precipitation technique will be completed and results evaluated. Bench scale research will be continued on processing variables to improve zinc and lithium recovery, as well as in the selective sulfide technique for recovering lead and zinc.

A study on control of silica scale formation from geobrine flow and its effect on mineral recovery was completed and a final report is in preparation. Other studies on the effect of geobrine scaling behavior will continue.

The Bureau began to collect data on the compositions of Western geobrines. Evaluation of additional geobrine compositions will continue and new brines will be considered for future minerals recovery research.

Completion of a project to screen materials of construction for geothermal brine operations is scheduled for FY 80. An agreement was signed with DOE to provide additional support in evaluating 4,000 samples of 20 iron-, nickel-, and titanium-based alloys tested in FY 78 at the Bureau of Mines' Salton Sea facility.

Corrosion/Deposition Studies. Corrosion and deposition are common to nearly all geothermal sites. However, each site has its own distinctive character. Most sites produce significant quantities of sulfur-containing gases such as H_2S which, when combined with moisture and air, form very corrosive acids. Geothermal fluids and emissions can be particularly corrosive, because of the aggressiveness of dissolved gases and chemical species associated with the geothermal fluid.

The purpose of the corrosion studies is to assess the impact of geothermal fluid on equipment and develop, where necessary, methods for mitigating such impacts. The corrosion study being conducted by the Navy at Coso (Cal.) seeks to establish corrosion evaluation techniques. Equipment is needed to evaluate effects of geothermal fluids on mechanical materials at remote Navy sites and the effects of airborne mists and aerosols on existing aircraft and electronic communication equipment. Measurement techniques will determine the nature and extent of geothermal emissions at given sites where visibility of other site-specific conditions is crucial to Navy mission performance.

In research on materials of construction for geobrine operations, evaluation of the corrosion behavior of the 20 iron-, nickel-, and titanium-base alloys (tested in FY 78 at the Bureau of Mines' Salton Sea facility) was started. Approximately 4,000 samples are involved. Maximum and average pitting corrosion rates were measured on 12 of the alloys, and an initial evaluation of localized corrosion effects was made. An agreement was signed with the Department of Energy to provide additional support for this evaluation, which will be completed in FY 80.

In FY 80, DOE will continue process R&D for lower cost H_2S and fluid treatment and procedures. Additionally, prototype components designed and manufactured from alternate materials will be field tested and demonstrated in small nonelectric and electric systems.

Hydrothermal Technology Development

DOE builds and tests facilities to demonstrate that the use of hydrothermal resources is technically feasible, economically sound, and environmentally acceptable. Demonstration will show that geothermal water use is feasible, provides vital engineering and economic data, and fosters the business infrastructure necessary for the private sector to continue Federal initiatives.

The specific objectives of the demonstration projects are:

- To operate by the end of FY 82 a commercial-scale electric plant capable of generating electricity from a superheated water hydrothermal resource
- To demonstrate with high confidence by FY 83 that a low-to-moderate salinity geothermal reservoir can provide an adequate supply of hot water for the extended operation of an electric plant
- To demonstrate by 1985 that the environmental effects of the construction and operation of an electric plant are acceptable
- To demonstrate by 1985 the production of electric power from hot water resources at a commercially competitive cost
- To demonstrate at Federal facilities the technical feasibility of selected nonelectric applications

The following hydrothermal experimental facilities are under construction or are being planned.

Raft River Facility. A pilot plant now being built has a 5 MWe turbine generator with a binary Rankine power cycle, and will use energy from a moderate-temperature hydrothermal resource (150°C) to generate electricity for a utility power grid. The objectives of the project are to compare costs and methods of geothermal power generation to those of conventional systems, to verify cost assumptions; and to supply valuable information on the geothermal reservoir, plant equipment, and plant operations for use in planning future generation systems. Work on the current construction contract is about 80 percent complete. The system is to be fitted with a turbine generator set, and additional well tests are to be undertaken. An Elliott turbine is scheduled for January 1980 delivery. This plant is expected to be operational by the end of FY 80.

At the Raft River site, geothermal energy was used not only in the fermentation of sugar beet syrup, but also in the distillation of the alcohol formed in the process. The process was carried out at about 116°C.

The world's first successful extraction of spearmint oil using conventional steam distillation processes with moderate temperature hydrothermal fluids was conducted at the Raft River facility. A good co-location of product and geothermal resources exist because Idaho, Washington, and Oregon produce the bulk of spearmint oil for the nation. Another first is the completion of testing for the first successful well fracturing experiment in Well 4, where artesian flow was increased from 50 to 150 gpm. Hydraulic fracturing is a standard method used by oil and gas drillers, but this is a first-time application for geothermal.

50 MWe Demonstration Plant. In FY 77, Congress authorized DOE to carry out a geothermal demonstration project using a hot water hydrothermal resource. The project entails construction and operation of a commercial-scale (50 MWe gross output) electric power plant. The plant will also serve as a "pathfinder" for the regulatory process and other legal and institutional aspects of geothermal development. A cooperative agreement between DOE, Union Geothermal of New Mexico, and Public Service Company of New Mexico was signed in August 1979. The final EIS was prepared for release in January 1980. Plant design is under way at Baca Ranch (N.M.) and an order for a turbine has been placed.

HGP-A Geothermal Wellhead Generator. This project will evaluate the feasibility of using a wellhead generator to produce baseload electrical power. The generator will use the geothermal fluid from geothermal well HGP-A in the rift zone of an active volcano in the Puna District of Hawaii. The major power plant components will be mounted in such a way that they can be moved to other sites at some future date. The project is expected to lead to commercial applications of wellhead generators in remote areas of the western continental United States and Hawaii.

Construction of this facility is progressing and a turbine generator is on order. The geothermal well, which required recementing, is expected to begin operating in the first quarter of FY 80.

Geothermal Loop Experimental Facility (GLEF). Located near Niland (Cal.), the GLEF has established the feasibility of using flash-steam binary systems for electric power production from high-temperature, high-salinity resources. The project is being cost-shared with the San Diego Gas and Electric Company.

The first GLEF was constructed in 1975, and operated 1,000 hours before it was shut down for removal of accumulated scale, which took approximately two weeks. New plant designs incorporating redundant flash trains are expected to increase the plant's production capacity from well below 75 percent to over 85 percent, and to reduce energy production costs to below 38 mills/kWh in the 50 MWe size.

Recently developed preinjection treatments have effectively eliminated injection clogging problems. Additionally, problems of scaling and corrosion have been addressed and solved. Facility testing was completed FY 79. The data derived from the facility has prompted Magma Power Co. to agree to operate a 50 MWe plant on the site by late 1984.

Geothermal Component Test Facility (GCTF). This facility provides moderate-temperature, moderate-to-low-salinity geothermal fluid and supporting services to experimenters for testing of equipment and components used in advanced geothermal systems. Located at East Mesa (Cal.), the GCTF is currently being used by several DOE-sponsored and independent experimenters; it will be operational until demand for its use diminishes. Both Federally and commercially developed components are being tested.

Geopressured Technology Development

The program to develop the geopressured resource is divided into two activities: reservoir definition and environmental research.

Thousands of wells have penetrated geopressured aquifers in search of oil and gas in other horizons in the Gulf Coast sediments; the magnitude of the geothermal resource is being defined and delineated by logs from these wells. These studies, along with seismic surveys and core analyses, have located 70 areas with high potential for geopressured production. These studies are being supported by programs to test wells of opportunity (wells penetrating geopressured formations that will not be tested by the operator) and design wells drilled by DOE specifically to test geopressured aquifers.

A major accomplishment for FY 79 was DOE's successful drilling of a well in Brazoria County (Tex.). The well is completed and ready for long-term testing.

Other accomplishments:

- Two wells of opportunity tested in Louisiana produced brine saturated with methane.

- Delineating of geopressured aquifers was essentially completed in FY 79; this work will serve as the basis for drilling and testing programs in coming years.

Mapping, including the assembly of a computerized data base, will continue in FY 80. Emphasis will be placed on resolution of the large identified reservoirs, mapping deeper formations, and extending the work to previously unmapped areas. The sites proposed for tests of existing wells and for drilling of new wells will also be evaluated within this program.

About 10 new geopressured wells are planned through 1984; the same number of existing wells could be subjected to short-term tests. Increased funding in FY 80 will support the increased rate of new drilling, and the testing of wells drilled in FY 79. Somewhat less will be expended in FY 80 to support resource definition (mapping), because this part of the program is relatively mature. Environmental assessment and monitoring of well sites in Texas and Louisiana will be accelerated to keep pace with the test programs.

Hot Dry Rock Technology Development

The hot dry rock program evaluates the energy potential of the resource and supports development of new technical approaches for extracting energy from hot dry rock. After successful operation of a 5 MWt loop at the Fenton Hill site in New Mexico in 1978, the program was expanded to include a 40-50 MWt demonstration.

As a result of this program, DOE:

- Began Phase II drilling a 20-50 MWt energy extraction loop at Fenton Hill
- Began intensive site-specific evaluations near Mountain Home, Ida., and Crisfield, Md., for selection of additional experimental locations
- Began a two-year, industrial-economic study
- Completed a preliminary legal study.

Field projects evaluating the energy potential and characterizing sites have become vigorous and growing program elements. The Fenton Hill project is the largest of these, comprising analytical and laboratory support and, as appropriate, instrument and equipment development. Careful environmental surveillance at the test site and in the vicinity continues to support the thesis that HDR is one of the most environmentally benign energy sources.

In FY 81, the Phase II drilling at Fenton Hill will be completed, and steps will be taken to establish a 20-50 MW system. Future development and proving of an HDR reservoir at Fenton Hill will be conducted under an international agreement between the United States and the Federal Republic

of Germany (FRG). The FRG will contribute 25 percent of DOE's budget for the Fenton Hill project, up to a maximum of $2.5 million per year. The initial agreement will remain in effect for 4 years.

Based on data from resource evaluation and site characterization, a second HDR site will be selected in FY 81, to continue experiments in energy extraction technology.

E. RESOURCE IDENTIFICATION, ASSESSMENT, AND EXPLORATION

The objectives of the Federal resource identification program are to

- Characterize the geological nature of each type of geothermal system and the reservoirs within these systems
- Estimate the location, distribution, and energy content of individual geothermal systems and reservoirs
- Inventory the identified portion and predict the undiscovered portion of the nation's geothermal resources
- Confirm the existence and commercial potential of high- and moderate-temperature reservoirs suitable for electric power generation
- Confirm low- and moderate-temperature prospects that show potential for direct heat applications.

To achieve these objectives, DOE and the U.S. Geological Survey (USGS) undertake national, regional, and in cooperation with individual states, site-specific assessments of the geothermal resource (with emphasis on the hydrothermal resource). In addition, exploratory drilling programs have begun in several regions where a strong interest in direct heat has been exhibited, but where appropriate resources have not yet been confirmed.

National Geothermal Resource Update

The USGS completed a major update of its assessment of U.S. geothermal resources, and published the results in January 1979 as USGS Circular 790. The update reaffirms the existence of very large energy contents for hydrothermal, geopressured, and hot dry rock resource bases. (For more information, see Chapter II of this Report.) DOE's state-coupled program (see below) has increased state assessment activities, undertaken in concert with USGS. This Federal-state relationship will provide information on low-and moderate-temperature resource areas.

The National Energy Act of 1978 gives impetus to geothermal resource development in general by allowing investment tax credits, expensing of

intangible drilling costs, and a percentage depletion allowance. Specifically, these incentives should stimulate greater financial involvement by industry in exploration for and confirmation of geothermal reservoirs.

Reservoir Definition

USGS Assessment. A comprehensive, multi-year study of the Cascade Mountains of Washington, Oregon, and northern California is under way to determine the character and extent of geothermal resources of the region. It is being conducted by the USGS, state agencies, several universities, and several private firms. Reconnaissance studies have been initiated and will be followed by selection of a few areas for concentrated studies. In a related effort, DOE and USGS are jointly evaluating the resource potential of Mount Hood, Oregon.

Major aspects of a comprehensive, multidisciplinary investigation of the geothermal resource potential of the Snake River Plain region, spanning three years, were completed during FY 79. Results are being compiled into a regional case study.

The USGS has placed added emphasis on assessing geopressured resources by initiating a study of the deeper onshore and offshore portions along the Gulf Coast to characterize their structures, stratigraphic framework, and depositional environments for improved estimates of thermal and methane energy content.

Industry-Coupled Case Study. To accelerate confirmation of geothermal reservoirs with apparent commercial electric potential, the industry-coupled case study program was begun in FY 78. DOE shares exploration and drilling costs with industry, in exchange for public release of data; these data help in finding successful techniques for exploration, well drilling, and completion. In FY 79, nine companies participated. The program was extended to northern Nevada, where 12 candidate sites are being investigated for exploratory drilling in FY 80.

State-Coupled Program. Low- and moderate-temperature resources are being defined in cooperation with nearly all 37 states that have identified resource potential. The effort consists of two phases. Phase 1 analyzes existing geological and geophysical data to establish the size and distribution of hydrothermal resources. Phase 2 assesses target areas in detail and may drill heat flow measurement holes to confirm the existence and nature of the resource. Progress in FY 79:

- The Atlantic Coastal Plain project has delineated several probable reservoir targets as part of Phase 1. Therefore, in FY 80, a number of Phase 2 heat flow holes 1,000 to 2,000 feet deep will be drilled.

- Potential reservoirs have been identified in Arizona, California, Colorado, Idaho, Montana, New Mexico, Oregon, Texas, Utah, Washington, and Wyoming.

- Geothermal resource maps have been published for Oregon, Nevada, and Arizona; maps for Oregon and Montana are in press. Maps for most other states participating in the state-coupled program will be published in FY 80.

- Many data on low- and moderate-temperature hydrothermal resources are being added to the geothermal data file of the USGS, GEOTHERM, which provides the principal data bank for assessing these resources.

Exploratory Drilling for Low- and Moderate-Temperature Reservoir Confirmation

The use of hydrothermal energy for direct heat applications is hampered by the lack of resource knowledge and by the high risks and costs of reservoir confirmation. In addition, no infrastructure exists in the private sector to undertake the development of resources once they are confirmed. A limited exploratory drilling program has been carried out in several regions where there is strong interest in the use of hydrothermal energy for nonelectric purposes but where there is no confirmed resource.

DOE plans a much more aggressive program in FY 81, to be called the User-Coupled Drilling Program. Competitively selected teams composed of a developer and a user will share the cost of surface exploration and drilling to locate and confirm a reservoir that could be commercially developed for direct heat applications identified by the user.

In FY 79:

- A deep test well drilled at Crisfield (Md.) recovered warm water at 4,000 feet, 54°C at a potential flow rate of 325 gallons per minute. One or two more exploratory wells will be drilled in the Atlantic Coastal Plain during FY 80.

- A well was drilled to a depth of 10,500 feet at the Idaho National Engineering Laboratory (INEL). The purpose of the well was to locate moderate- to high-temperature fluids underneath the Snake River Plain, to be used as a source of heat for the chemical processing plant at INEL. The well temperatures registered 150°C but the volume of fluid sufficient to meet plant needs was not found.

- A well was drilled at the Los Alamos Scientific Laboratory in an attempt to provide an alternate energy source for the laboratory. The well was abandoned at 2,300 feet, because of lost circulation.

One or more deep wells will be drilled in the Mount Hood (Ore.) area in FY 80, as a result of a Congressional add-on. Interest has been expressed in the use of hydrothermal energy for district heating in the city of Portland and for space heating of facilities on or near Mount Hood.

The expanding economy of the Pacific Southwest is being maintained at the expense of a diminishing water supply. Current water demands, exceeding the annual renewable supplies, are being met by overdrafts of groundwater reservoirs. To augment the water-short area of the Colorado River Basin, the Water and Power Resources Service's geothermal investigations began in FY 78 to locate new sources of water supply: the geothermal brines are desalted by using the heat energy inherent in the geothermal fluid.

The Water and Power Resources Service (DOI) is conducting reconnaissance-level geothermal investigations throughout the Colorado River Basin, with special emphasis on the Springerville-St. Johns and Clifton areas of Arizona. The service provides drilling capability for heat flow and other geophysical studies being performed by the University of Arizona. Five temperature-gradient holes 500-1,500 feet deep have been drilled this past year in the Springerville area and one 1,000-foot hole was drilled in the Clifton area. Logging of new and existing wells is continuing. Electronic mapping is being done by the University of Arizona. After data are collected, the University will prepare and publish a total geothermal resource report in FY 80.

The Service also drilled five temperature gradient holes 200 feet deep in the Mono Lake area of California during the past year. Water supply studies from geothermal resources will continue through FY 80. Geothermal studies in the Salton Trough area (Cal.) are now limited to literature research and geothermal water supply studies using existing data. This work is expected to be completed in FY 80. A final report describing the desalting program at the East Mesa Geothermal Test site is expected by early FY 80. In the Susanville area, the Service drilled 10 temperature-gradient holes 400-900 feet deep. Only minor work, such as pumping tests and installation of casing in several holes, remains to be done. WPRS will drill eight 150-foot temperature gradient holes in the Litchfield area and may extend one or two holes to 1500 feet during FY 80. A pump test will be run in the deeper hole. Geophysical surveys will continue in both Susanville and Litchfield with a final report due by the end of the year. No funding for geothermal field work in Susanville is scheduled after FY 80.

Resource Assessments on BLM Lands. Under the provisions of the Federal Land Policy Management Act (FLPMA), the Bureau of Land Management is developing recommendations to Congress for certain lands to be designated wilderness areas. These areas should generally be 5,000 contiguous acres or more of roadless lands that have opportunity for primitive and unconfined recreation. After such areas are identified, an interim mangement policy allowing for assessment of mineral and energy resources will be implemented. A final management policy for BLM lands will be recommended to Congress by 1993.

At present, BLM is identifying and taking inventory of roadless areas, and will complete this task by October 1980. After that, comprehensive resource assessment studies will begin. It is anticipated that roadless tracts containing vital mineral resources will be released for development before 1993.

DOE will take an active role in resource assessment for energy minerals, and will advocate nonwilderness classification of energy-rich lands. Therefore, with support from a national laboratory, the Leasing Policy Development Office (LPDO) of DOE has begun its own resource assessment on BLM's Wilderness Study Areas (WSA).

The Division of Geothermal Resource Management has been working closely with LPDO in planning for the assessment and ranking of geothermal resources on BLM Wilderness Study Areas. WSAs with known or suspected geothermal resources have been identified in a preliminary manner, and criteria for ranking of geothermal resources are under development. Over the next several years, DOE will maintain an active role in the Wilderness Study.

F. LEASING

The Federal leasing program is an important determinant of the rate at which geothermal resources will be developed in the United States. The experience of Federal leasing agencies since the passage of the Geothermal Steam Act has demonstrated how difficult it is to balance rapid resource development, especially in areas of technological uncertainty, against environmental values and sound land management practices.

Regulations implementing Federal leasing took effect in December 1973, and the first leases were issued in 1974. The first commercial production of geothermal energy from Federal lands began in 1979 at the Geysers in California--nearly 20 years after production began there on non-Federal lands.

At the end of FY 79, over 2.8 million acres had been leased: 296 competitive leases on 510,000 and 1,332 noncompetitive leases on 2,315,000 acres (Tables ES-4 and V.7). While this is a substantial acreage, it may not be enough. To achieve the IGCC's goals for the year 2000, an estimated 20-40 million acres will have to be explored by 1990. About half of that will be Federal lands. The requirements for environmental reviews and land-use planning, coupled with limited manpower and budgets, have seriously delayed issuance of leases in Forest Service lands. Furthermore, the issuance of noncompetitive leases has been slow in some states. About 1.3 million acres in Known Geothermal Resources Areas (KGRAs) have not been offered for competitive sale. Tables V.3 through V.8 present detailed breakdowns for competitive and noncompetitive leasing over the past several years.

The U.S. Geological Survey designates certain lands Known Geothermal Resource Areas, based on strong evidence of geothermal resources. To date, 3.38 million acres have been designated KGRA lands, 2.15 million acres (64 percent) of those on Federally administered lands. The Geysers Known Geothermal Resource Area alone has accounted for over $24 million in high

bonus bids, which is 65 percent of the total bonus bids accepted since the first Federal geothermal sale in 1974. About 35 percent of the KGRA acreage offered for competitive sale has not been bid upon. Almost one-fourth of all leases issued have been relinquished, and a substantial number of leases offered to applicants have been rejected.

The U.S. Geological Survey provides permits and monitors development on leased lands. Of the 1,628 outstanding leases issued since 1974, 129 plans of operations for exploration have been approved, and 192 wells drilled. About 400 exploratory operations have been approved on unleased land. Twenty-five of the on-lease exploratory plans were filed since the passage of the National Energy Act in October 1978; thanks to the tax incentives in this Act.

BLM Leasing

According to industry sources, accelerated leasing of Federal lands may be accomplished by changing some of the BLM's leasing regulations and procedures. In FY 80 BLM plans to focus activity on relieving two major obstacles to Federal leasing. First, regulations will be drafted to allow reissuance of 343 relinquished leases. Second, a new environmental assessment procedure will be implemented to match the level of review with the proposed activity. These two changes, accompanied by a legislative revision of maximum acreage limitation currently being considered by the Congress could very substantially affect the amount of acreage leased.

Believing that the key to direct use development lies in cooperation among state and Federal agencies, local governments, and small businesses, BLM is planning state-specific training and orientation meetings for its field managers, with participation from various state geothermal coordinators on contract to DOE. BLM will issue specific instructions for processing direct use applications in its local field offices. To make the process much easier for the applicant, the instructions will, as much as possible, include state requirements.

USFS Leasing

A letter drafted late in FY 79 by the U.S. Forest Service advised its regional foresters of a reorientation in the policy concerning mineral-related activitites. Citing a backlog of several hundred geothermal leases, some pending for several years, the letter states, "Our objective is to eliminate this backlog within 2 years, while keeping current with new applications".

To accomplish this, regional foresters were told that there is no legal reason to withhold action on leasing pending completion of Land Management Plans. This advice is intended to speed up leasing by allowing applications to be processed before completion of Forest Plans under the National Forest Management Act. Further, the regional foresters were advised of plans to establish reasonable time limits for leasing and permitting decisions, to require that applicants be promptly notified of decision schedules, and to make those schedules appealable.

Only about 5 percent of geothermal noncompetitive lease applications for National Forest System lands have led to leases being issued. However, that figure does not indicate the significant efforts of the past two or three years. For example:

- On May 15, 1979, the Regional Forester for the Pacific Northwest Region signed a final Environmental Statement that approved leasing of 192,310 acres in the Gifford Pinchot National Forest in Oregon and denied leases for 107,298 acres. About 100 leases are involved--nearly 10 percent of the Forest Service's total backlog of pending applications.

- The Island Park Geothermal area, west of the Yellowstone National Park, has nearly 130 pending lease applications, or about 13 percent of the total backlog. In cooperation with the BLM, FS issued a draft environmental statement in March 1979,which discussed a number of leasing alternatives; the final environmental statement was in preparation at the end of the fiscal year. There is considerable controversy over possible effects on Yellowstone National Park, and even if FS consents to lease National Forest System lands, the Department of the Interior may refuse to issue the leases.

With regard to competitive leasing, about 12 percent of those KGRAs wholly or partly on National Forest System lands have been offered for sale. Some offered KGRAs have not received any bids. The majority of the KGRAs have not been proposed for leasing by BLM because of apparent lack of industry interest. Only a few KGRAs are considered to have potential for electric generation. Two of these, West Yellowstone KGRA and Island Park Competitive KGRA, are covered in the draft environmental statement discussed above. The Mono Long Valley KGRA of California has been the object of considerable interest from the geothermal industry; the Forest Service is now in the final stages of prelease review, and a sale has tentatively been scheduled for early 1980.

Based on recommendations of the IGCC's Streamlining Task Force, a pilot test of staged leasing using a (conditional development) stipulation was approved for use in Oregon and Washington State National Forests. A successful outcome will encourage staged leasing elsewhere on Forest Service lands. Staged leasing derives from the idea that to perform a full-scale environmental review of possible development before any leasing begins is often to waste both money and time, and cannot meet the intent of the National Environmental Policy Act (NEPA), since the location, type, and scale of development are unknown. As set up in the Forest Service test areas, lease issuance will be based primarily on environmental review of exploration. If the lessee discovers a commercially viable resource and presents a plan of development, a comprehensive environmental review of that plan will be conducted before development can begin.

Essentially, this process is already in effect. The value of the stipulation is primarily to serve notice of the process and thereby provide a clear rationale for not attempting to fully address development in the pre-lease review.

Table V.3
COMPETITIVE LEASING BY STATE
TOTAL ACREAGE LEASED, BY YEAR

STATE	1974	1975	1976	1977	1978	*1979	Total
Nevada	28,338	29,197	60,944	36,663	9,322	24,298	188,763
Utah	23,391	26,171	26,968	12,788	1,658	-0-	90,977
New Mexico	-0-	18,476	14,088	48,066	8,767	7,062	96,461
Oregon	1,374	47,689	19,836	-0-	5,818	-0-	74,691
California	26,007	10,583	-0-	2,856	4,395	6,958	50,802
Idaho	-0-	20,963	3,940	6,985	-0-	-0-	31,889
Colorado	-0-	5,036	-0-	-0-	-0-	-0-	5,036
Total acres leased (by year)	79,110	158,115	125,776	107,358	29,960	*38,318	*538,619

*September 1979.

Table V.4

TOTAL HIGH BONUS BIDS BY STATE AND YEAR (IN DOLLARS)

State	1974	1975	1976	1977	1978	1979	Total
Cal.	8,614,912	134,532	-0-	780,451	16,016,169	1,368,191	$ 26,914,257
Utah	877,188	2,705,618	96,688	668,825	33,862	-0-	4,382,184
Nev.	1,030,172	392,160	757,991	451,984	480,893	657,469	3,770,671
N. Mex.	-0-	359,682	54,901	1,089,213	72,639	240,631	1,817,070
Ore.	13,831	296,798	140,251	-0-	86,531	-0-	537,462
Ida.	-0-	153,470	27,006	30,452	-0-	-0-	221,929
Colo.	-0-	13,577	-0-	-0-	-0-	-0-	13,577
Total	10,536,103	4,055,837	1,076,837	3,020,925	16,690,094	2,266,291	37,657,150

Table V.5

DISTRIBUTION OF COMPETITIVE LEASE SALES BY STATE AND YEAR

	CY 1974	1975	1976	1977	1978	*1979	Total
Western Region:							
Nevada.....	2	3	7	3	1	1	17
California.....	3	1	0	1	2	1	8
Oregon.....	1	5	3	1	2	0	12
Idaho.....	0	2	2	1	0	0	5
Arizona.....	0	1	0	0	0	0	1
Subtotal.....	6	12	12	6	5	2	43
Central Region:							
New Mexico.....	0	1	2	3	1	1	8
Utah.....	1	2	1	1	1	0	6
Colorado.....	0	1	0	1	0	0	2
Montana.....	0	0	0	1	0	1	2
Subtotal.....	1	4	3	6	2	2	18
Total.....	7	16	15	12	7	4	61

*(September 1979)

Table V.6

CUMULATIVE NONCOMPETITIVE LEASE TOTALS, 1976-1979

Year (June 30)	Filings	Withdrawn, Rejected, & Refused	Awaiting Action	Leases Issued	Acreage Leased
1976	5,432	2,734	2,012	656	1,141,980
1977	6,043	3,232	1,831	904	1,500,005
1978	6,655	3,673	1,806	1,117	1,930,163
1979	7,315	4,027	1,956	1,332	2,314,670

Table V. 7

NONCOMPETITIVE GEOTHERMAL LEASING, 1979

STATE	APPLICATIONS								LEASES					
	FILED			INACTIVE			AWAITING ACTION		ISSUED			ACRES		
	BLM	FS	SUBTOTAL	WITHDRAWN	REJECTED	REFUSED	BLM	FS	BLM	FS	SUBTOTAL	BLM	FS	SUBTOTAL
Alaska	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Arizona	64	67	131	7	35	8	13	55	12	1	13	19,621	1,920	21,541
California	730	460	1190	389	303	0	245	233	20	0	20	32,584	0	32,584
Colorado	113	83	196	100	17	2	6	38	42	1	43	49,565	680	50,245
Idaho	649	332	981	270	175	30	164	176	165	1	166	291,385	2,560	293,945
Montana	38	66	104	54	26	0	18	0	6	0	6	10,687	0	10,687
Nevada	1655	13	1668	542	356	78	165	0	524	3	527	981,184	4,434	985,618
New Mexico	629	42	671	337	83	10	109	19	113	0	113	194,318	0	194,318
Oregon	638	526	1164	243	295	0	134	351	118	26	144	161,041	43,437	204,478
Utah	584	108	692	172	149	22	31	33	274	11	285	480,551	13,513	494,064
Washington	0	342	342	105	61	0	0	176	0	0	0	0	0	0
Wyoming	26	138	164	141	16	0	1	2	0	4	4	0	7,448	7,448
East'n. States	0	12	12	0	1	0	0	0	0	11	11	0	19,744	19,744
TOTALS	5,126	2,189	7,315	2,360	1,517	150	886	1,083	1,274	58	1,332	2,220,936	93,736	2,314,672

(1) Applications awaiting action for the following reasons:

- 34 Awaiting KGRA report from USGS
- 1 Pre-lease plan of development
- 597 Pending preparation of EAR (BLM only)
- 1004 Awaiting comment of other agencies
- 30 Lease forwarded for signature
- 290 Processing (Adjudication) -- BLM

Table V. 8

NONCOMPETITIVE GEOTHERMAL LEASING
APPLICATIONS AWAITING ACTION

STATE	AWAITING KGRA REPORT FROM USGS	AWAITING PRE-LEASE PLAN OF DEV. FROM APPLICANT	PENDING PREP OF EAR (BLM ONLY)	AWAITING COMMENT OF OTHER AGENCIES Other	FS	LEASE FORWARDED FOR SIGNATURE BY APPLICANT	PROCESSING (ADJUDICATION) BLM	TOTALS
Alaska								
Arizona			13		55			68
California			230	11	233		4	478
Colorado					28		6	34
Idaho	3		130		173		34	340
Montana			8		10			18
Nevada	26		9		14	15	101	165
New Mexico	5		65		29	8	21	128
Oregon			134		340	6	2	482
Utah		1	7	4	33	1	18	64
Washington					72		104	176
Wyoming			1		2			3
Eastern States								
SUBTOTAL	34	1	597	15	989	30	290	1,956

The Forest Service intends that with increased emphasis on mineral activities, lease processing will be accelerated, and subsequently the entire geothermal program on National Forest Service Lands.

G. ENVIRONMENT

The Federal environmental program includes acquisition of baseline data, monitoring, and research related to air and water quality, ecology, noise, subsidence and seismicity, health effects and socioeconomic problems; regional and site specific assessments of the environmental, health, and socioeconomic impacts of the development of geothermal resources; development and assessment of environmental control technologies; and the promulgation of regulations to protect the environment from the adverse effects of exploiting geothermal resources.

The DOE, EPA, and DOI have been the principal supporters of the environmental program, with DOE sponsoring most of the research activities. DOE and EPA have increased their funding for cooperative projects over the past few years.

Environmental Studies and Control Technology

Assessment. In FY 79, DOE and EPA continued to prepare environmental assessments and develop control technologies begun in previous years.

The Geothermal Environmental Overview Project (GEOP) sponsored by DOE is a major effort to identify and assess current information of potential environmental concerns in those Known Geothermal Resources Areas having a high probability of commercial development. Preliminary assessment reports issued in FY 79 included The Geysers-Calistoga area, and the Texas-Louisiana Gulf Coast. Assessments were initiated at Hawaii, Oregon, New Mexico, and northern Nevada, and are continuing for Mono-Long Valley, Raft River, and Roosevelt Hot Springs.

Other developments include:

- The GEOP's preliminary assessment of the Geysers-Calistoga KGRA, which pointed to potential socioeconomic problems. As a result DOE initiated a study of socioeconomic impacts resulting from geothermal expansion in this region. This study will be completed in FY 80.

- An extensive field measurements program to establish a baseline for future development in the Imperial Valley, (and to serve as a knowledge base for other studies), which has been completed. Data are being formatted for access by potential users, and analyses are available.

- A technology assessment integrating the environmental, economic, and social impacts of full-scale development of geothermal resources in the

Imperial Valley has been completed by DOE and will be published in FY 80.

- Continued preparation of programmatic environmental assessments and site specific Environmental Impact Statements (EIS) for DOE's development activities. The most significant of these was the EIS for the joint DOE-Industry 50 MWe powerplant development at Baca Ranch in New Mexico, published in January 1980.

- A subsurface environmental assessment by EPA for four geothermal systems: Imperial Valley (Cal.); The Geysers (Cal.); Klamath Falls (Ore.) and Valles Caldera (N.M.). As part of that project, a groundwater monitoring methodology was developed and its demonstration initiated.

- Initiation of a major program of specific and generic environmental studies using the 50 MWe hydrothermal demonstration project at Baca Ranch (N.M.).

- Data gathering by DOE and EPA on chemical and physical characteristics of geothermal fluids, including both liquids and gases, at existing and potential development sites.

H_2S Emissions. DOE has compiled all available information on H_2S control technologies applicable to geothermal emissions, including information gathered in recent applications, both new and retrofitted.

EPA initiated a project to examine the concept of electrochemical H_2S oxidation. If successful, this concept offers several advantages, not the least of which is that the only raw material operational requirement is electricity, ideal for power plant application.

DOE and EPA jointly initiated a project to develop UOP's sulfox process to remove H_2S while producing a usable by-product (sulfur) rather than creating solid waste or other disposal problems.

A demonstration of the EIC process, a prototype system to scrub 100,000 pounds of raw steam per hour, began at The Geysers. The initial results are very encouraging. Supported by DOE, EPA, and Pacific Gas & Electric Co., this system offers the opportunity to remove H_2S during steam stacking when the plant is shut down.

Subsidence and Seismicity. USGS requires baseline monitoring of subsidence at geothermal projects on leased Federal lands, and can shut down plants on evidence of seismicity. The Coastal Zone Management Act administered by the Department of Commerce contains a subsidence provision as well.

DOE continued its subsidence research, establishing the Geothermal Subsidence Research Program with the objectives of characterizing,

measuring, predicting and mitigating subsidence. This year, DOE completed an assessment of the environmental and economic effects of subsidence and prepared a manual of guidelines for monitoring surface displacements. Projects to assess mathematical subsidence models, to study the compressibility of reservoir cores, and to study the compaction properties of reservoir materials were continued. Case histories of subsidence were prepared for Long Beach, California, and Wairakei, New Zealand. Analytical models were developed for comparison with observed data. Near-future projects will include a detailed case history for Chocolate Bayou (Tex.), a subsurface risk assessment, and an assessment of potential indirect measurement techniques.

A major program to understand, predict, and mitigate induced seismic activity from geothermal development is in progress by USGS and DOE. A study to evaluate the effectiveness of current seismic control techniques has begun and is due in FY 80. Monitoring nets were emplaced in northern Nevada, at Roosevelt Hot Springs (Utah), and at The Geysers Field in California to detect and measure induced seismicity.

Liquid and Solid Waste Treatment and Disposal. Liquid waste treatment and disposal have not received great attention to date. It has been assumed that subsurface injection would provide reservoir conservation, subsidence prevention, and pollution control. DOE and the Department of Interior continue to experiment with methods and materials that reduce the potential for corrosion failure and for plugging of injection systems by chemical precipitation. DOE continues to investigate the need to treat Imperial Valley geothermal fluids and methods to dispose of solid waste residuals. EPA intends to begin an assessment of the overall geothermal solid waste problem in FY 80.

Other activities include

- A project initiated by EPA and the U.S. Fish and Wildlife Service in FY 79 to determine the feasibility of using spent geothermal fluids to create or enhance waterfowl wetlands. DOE is also examining surface uses at its Raft River (Ida.) test site.

- A project completed by EPA to develop a methodology for determining the ground water contamination potential of fluid releases at any point in the geothermal conversion system. Other EPA projects completed in FY 79 estimated the costs of pollution control technologies and examined the need for surface containment of potential brine spills.

- Plans by EPA to initiate broad-scale environmental assessments of spent fluid injection and of ocean disposal, the latter applying particularly to the Gulf Coast geopressured area.

Noise. DOE began the study of geothermal noise and state-of-the-art abatement measures. The project will address both general and site-specific problems. Although noise in geothermal operations can be intense, it appears to be controllable and therefore will not seriously constrain geothermal development. A report will be available in FY 80.

Table V.9

ENVIRONMENTAL AND CONSERVATION LAWS AFFECTING GEOTHERMAL DEVELOPMENT

Geothermal Steam Act of 1970

National Environmental Policy Act of 1969

Federal Water Pollution Control Act, as Amended

Clean Air Act, as Amended

Resource Conservation and Recovery Act

Safe Drinking Water Act

Federal Land Policy and Management Act of 1976

National Forest Management Act of 1976

Endangered Species Act of 1973

National Historic Preservation Act of 1966

Noise Control Act of 1972

Coastal Zone Management Act of 1972

Wild and Scenic Rivers Management Act

Wilderness Act and other Conservation Statutes

The Marine Protection Research and Sanctuaries Act

Environmental Policy and Regulatory Development

Table V.9 lists the current laws affecting geothermal development. Hazardous waste guidelines and regulations were proposed December 18, 1978 (40CFR Part 250) by EPA under the Resource Conservation and Recovery Act. Under the criteria in these regulations, geothermal drilling wastes and brine treatment residuals would probably be classified as hazardous (toxic) wastes. Congress is considering amendments to the Resource Conservation and Recovery Act that would include the temporary exemption of geothermal solid wastes from regulation as hazardous wastes, at least until studies are made of their character, control methods, and control costs.

Regulations for state underground injection programs were reproposed April 20, 1979 (40CFR Part 146) under the Safe Drinking Water Act. The regulations as reproposed would allow states to exclude groundwater aquifers as drinking water sources on the basis that they produce geothermal energy. Thus, injection could be allowed to these aquifers whether or not they otherwise met the criteria as drinking water sources. The proposed regulations now divide injection into five classes; geothermal injection wells are included in Class III, special process injection wells. Each class has specific requirements for construction, abandonment, operating, monitoring, and reporting. Of particular significance are the proposed monitoring requirements which include at least five monitoring wells at each injection site.

Both the hazardous waste and the injection regulations will be intensively reviewed and revised before their final promulgation.

The Prevention of Significant Deterioration (PSD) provisions of the Clean Air Act as amended have significant implications for geothermal energy development, with respect to hydrogen sulfide (H_2S) emissions. The PSD regulation amendment, proposed September 5, 1979, indicate that each permit application will be reviewed and that wherever emissions of a criterion pollutant total 250 tons per year or more, best available control technology will be required. Where the actual emissions, whether raw or controlled, are less than 250 tons per year, the PSD requirements will not be applied, although, of course, the state ambient air quality standards must still be met. The proposed regulations recognize court decisions that would, in effect, exclude geothermal operations from PSD requirements since they are not major sources of criteria pollutants. H_2S is not a criterion pollutant, but the resulting sulfur oxide would have fallen under PSD.

The Environmental Protection Agency intends to update its "Pollution Control Guidance for Geothermal Energy Development" during FY 81. The revised document is likely to define three separate categories of geothermal development--hydrothermal, geopressured, and hot dry rock--with the possibility of somewhat different guidance for each.

Environmental Status of Geothermal Loan Guaranty Program Projects

DOE issued an Environmental Assessment of the exploratory phase and full field development for California-Utah (CU1) project at South Brawley,

Imperial County, California. A Notice of Intent to write an Environmental Impact Statement for full field development and power plant construction was published in the Federal Register in December 1978.

For the Westmorland Project in the Imperial Valley (Cal.), involving development of geothermal resources on privately owned leased land, DOE issued an Environmental Assessment in May 1979. This EA asserted that there are no major environmental problems associated with the project's exploratory phases. An Environmental Impact Statement will be prepared before power plant construction and operation.

On June 12, 1979, DOE's Assistant Secretary for Environment issued a finding of no significant environmental impact for Republic Geothermal's project at East Mesa, Imperial Valley, California. Hence, an Environmental Impact Statement will not be required by DOE for the 48 MWe power plant.

In June 1979, DOE, the Department of Interior, State of Utah officials, and leaseholders met to discuss Federal/state environmental requirements for power plant sitings in the Roosevelt Hot Springs (Utah) geothermal area. Further meetings were held to prepare an interagency Memorandum of Understanding, and to prepare an implementation plan and schedule for environmental assessments. DOE will be involved only if the resource developer and power plant owners choose to finance those projects through the Geothermal Loan Guaranty Program.

H. POLICY DEVELOPMENT

The President, in his April 1977 energy message, directed the Departments of Interior and Agriculture to streamline their procedures for leases and environmental reviews of geothermal resources. An interagency Streamlining Task Force was formed and conducted a number of public workshops and meetings to identify problems and concerns surrounding geothermal development. The report of the Streamlining Task Force was transmitted to the IGCC for consideration. The IGCC approved 16 of the 19 recommendations contained in the report, and directed the Institutional Barriers Panel to work toward implementing those recommendations. (Recommendations 12 and 16, and part of recommendation 7 of that report were not approved). Table V.10 presents these recommendations and the actions taken.

During the meetings of the Streamlining Task Force, the acreage limit was the problem most cited as a barrier to exploration and development, and an increase was uniformly supported by industry, state government, and environmental and public interest groups. In an informal survey conducted in support of the Task Force, of 40 percent of companies who had terminated Federal leases, all but one company identified the acreage limit as a major problem and a primary reason for lease relinquishment.

Legislation

The Energy Tax Act of 1978 provided substantial tax incentives for geothermal energy, including depletion allowances of 15-22 percent,

Table V.10

STATUS REPORT
STREAMLINING TASK FORCE RECOMMENDATIONS

	RECOMMENDATION	ACTION
1.	Establish a permanent task group to review and make recommendations to review DOI/DOA/DOE Geothermal Regulations and Special Lease Stipulation Policy.	Establishment of Leasing and Permitting Committee (L&PC) was recommended and members have been named. This committee would interrelate strongly with designated agency field coordinator (recommendation 4) and report to IGCC. Field coordinators have not been appointed.
2.	Compile a comprehensive handbook of regulations with flow diagrams.	None as yet; suggest this be a high-priority L&PC task.
3.	Initiate a training and education program for Federal Field Managers with management responsibility in the geothermal program.	BLM workshop proposal deleted from Annual Work Plan by the meeting and workshop committee. Will try again next year.
4.	Establish coordinators, modify agreements, and improve coordination among and with Federal, state, and local government agencies.	None.
5.	Increase program priority for and management commitment to geothermal development.	Would be accomplished incidental to implementation of other recommendations. However, the deleted workshops were integral part.
6.	Require a response within 30 days for noncompetitive lease applications and indicate anticipated actions and time requirements.	Has been stalled because of legislative proposals.
7.	Require a 30-day time limitation on post-lease response to permit applications and allow Lease extension and rental suspension commensurate with agency delay.	Second part was remanded by IGCC; first part is in process of implementation.

Table V.10

STATUS REPORT
STREAMLINING TASK FORCE RECOMMENDATIONS
(Continued)

	RECOMMENDATION	ACTION
8.	Revise Geothermal Lease Form.	Suggested revision has been made—needs to be typed and distributed for review by DOE solicitor.
9.	Modify BLM nationwide-statewide Geothermal Resources Exploration Bond Form so as to be acceptable to all surface management agencies.	Modified in revision of lease form—to be reviewed.
10.	Modify Proposed Power Plant Siting regulations to clarify readjustment of rentals.	None.
11.	Review and revise KGRA Designation Criteria.	Included in a legislative proposal.
12.	Subject to normal adjudication, issue a noncompetitive lease unless the area is in a KGRA at the time of application.	Remanded for further study. However, it is included in a legislative proposal.
13.	Provide, as an alternative, leases based upon separate environmental assessment of exploration and development phases.	Stipulations approved for Forest Service implementation; letter sent to Region Six of the Forest Service on July 6, and immediately sent to forest supervisors for use.
14.	Use generalized, areawide environmental assessment through the land management planning process in pre-lease review and detailed site-specific studies only for post-lease actions.	As recognized by the task force, this procedure varies by states. It was recommended to provide emphasis. There have been no changes.
15.	Expedite the wilderness/roadless review process and prioritize study areas where geothermal potential is high.	Areas of known energy potential will receive priority.

Table V.11

GEOTHERMAL ENERGY OMNIBUS LEGISLATION: COMPARISON OF BILLS
as of September 30, 1979

ISSUE	CHURCH	MCCLURE	ADMINISTRATION
I. Loan Guaranties and Other Subsidies			
- 90% guaranties for municipals and cooperatives	x	x	no
- 90% guaranties for small business		x	no
- Reservoir insurance and reinsurance			no
- Direct 90% forgiveable loan-feasibility studies		x	x
- Direct forgiveable loans--exploratory drilling	x		grants
- Direct 75% loans--construction		x	no
- SBA, HUD, REA, FmHa use of GLGP		x	use existing authority
- 4-month time limit on GLGP processing		x	9 month
- Duplicative NEPA reviews prohibited		x	
- Expedited procedures for nonelectric GLGP applications		x	
II. Geothermal Steam Act			
A. Competitive/Noncompetitive Leasing			
- Increase acreage limit to 51,200	Couple with oil and gas limits	Also 248,000 acre overall limit	x
- Exempt developed acreage	x	x	producing
- KGRA definition--discoveries only	x		(substantial geological criteria) competitive interest

Legend: Church - position taken in S. 1388/H.R. 5187
McClure - position taken in S. 1330/H.R. 4471
Administration - position taken, with OMB clearance, by Administration
no - opposed
x - in agreement
blank - no position taken

Table V.11

GEOTHERMAL ENERGY OMNIBUS LEGISLATION: COMPARISON OF BILLS
(Continued)

ISSUE	CHURCH	MCCLURE	ADMINISTRATION
- KGRA definition-electric only	x	60MWe	criteria for nonelectric
- Noncompetitive applications exempt from KGRA designation	public notice procedure	x	x
- Declassification of unbid KGRA lands	x	also if unleased 12 months after designation	x
B. Procedural Streamlining			
- Conditioned leasing	includes NSO lease	x	x
- Time limits	x	very stringent goals	x
C. Other			
- Free use permits	x	x	x
- Federal use authorized	x	x	x
- Authority to negotiate lease		permits	
- Elimination of "steam" references	x	x	x
- Clarification of authority for withdrawn and acquired lands	x	study	x
- Diligence requirements	x		modified
- Alternative bidding procedures	x		x
- Relief from 10-year readjustment authority	x		x
- Production goals		x	x
- Interagency Leasing Committee		x	

Table V.11

GEOTHERMAL ENERGY OMNIBUS LEGISLATION: COMPARISON OF BILLS
(Continued)

ISSUE	CHURCH	MCCLURE	ADMINISTRATION
C. Other (Continued)			
- Requires implementation of STF recommendations (handbook, field coordinators, training program, budget coordination, interagency agreements coordination with states, permanent task force)		x	
- Inclusion of geothermal in land use plans		x	expanded
- "Raw land value" a rental basis		x	provided by regulation
III. Tax Amendments			
- 10% Investment tax credit for utilities until 1990		x	no
- Elimination of minimum tax on intangible drilling cost (IDC) deduction		x	no
- IDCs for injection wells		x	not needed
IV. Fuel Use Act			
- Exemption from geopressured methane			(done by regulation)
V. Public Utility Regulatory Policy Act			
- Geothermal included in small power producer category		x	x
- Increase 30 MWe regulatory exemptions		x	80 MWe
VI. National Energy Conservation Policy Act			
- Federal Buildings Program		x	x
- HUD, FmHA mortgage limit extension			x

Table V.11

GEOTHERMAL ENERGY OMNIBUS LEGISLATION: COMPARISON OF BILLS
(Concluded)

ISSUE	CHURCH	MCCLURE	ADMINISTRATION
VI. National Energy Conservation Policy Act (Continued)			
- Schools and hospitals program		x	x
- Secondary financing and loan insurance (GNMA)			x
VIII Priority Geothermal Project Act			
- Procedures for certification and NEPA exemption		x	
- Automatic qualification for publicly owned utility nonelectric projects and for power plants greater than 10 MWe		x	

intangible drilling cost deductions, a 10 percent business investment tax credit, and credits for residential applications of geothermal energy.

These actions at the Federal level were supplemented by state actions such as California's definition of geothermal energy as a preferred energy source and reduction of its geothermal power plant siting time to 12 months, and the formation by the Pacific states of geothermal development coordinating councils to foster rapid geothermal growth. Notwithstanding the gains made from these actions, other legislative remedies are needed to bring geothermal energy into a competitive position.

In FY 79 four bills were introduced on Capitol Hill: S. 1338, introduced by Sen. Church (D-Idaho) and its companion H.R. 5187, introduced by Reps. Udall (D-Arizona) and Santini (D-Nevada); and S. 1330 introduced by Sen. McClure (R-Idaho), and its companion bill H.R. 4471, sponsored by Rep. Symms (R-Idaho). In addition, several changes to geothermal tax credits are proposed in the Windfall Profits Tax legislation now before Congress, and extensive amendments to the 1970 Steam Act are proposed in other pending legislation.

In its review of the recommendations from the Streamlining Task Force, the IBP presented an Omnibus bill to the IGCC incorporating those suggestions. The work of the IBP became the basis for several of the bills listed above. Table V.11 presents the original position of the IBP and the major provisions of these bills. The Administration is reviewing its position. In September 1978, the Institutional Barriers Panel, in a report to the IGCC, discussed various regulations affecting geothermal energy development, and suggested certain approaches to be used in writing new regulations and changes to be made in existing regulations.

The IBP is also reviewing manpower training needs and will recommend specific actions to the IGCC. The National Conference of State Legislatures, under a grant from DOE, is conducting a study of state laws and regulations affecting geothermal development, and regularly conducts workshops for state legislators and authorities. The major feature of the NCSL project activities is direct technical assistance to state legislatures. This generally means a four-phase process consisting of project introduction/resource overview; state-specific issues identification; analysis of policy options; and legislative recommendations, including draft legislation. Background materials are available, and efforts are coordinated with state regulatory agencies and private as well as public developers. In addition, NCSL provides tracking of state geothermal legislation, advises DOE geothermal contractors, and participates with the geothermal operations research effort.

Other issues being examined by the IBP include questions of royalty payments and tax exemptions. The requirement for royalty payments is hampering nonelectric development, particularly where no sale of the resource occurs. Both DOE and USGS are reviewing for residential tax exemptions are in question. The IRS issued draft regulations on May 23, 1979 proposing a minimum of 60°C for a resource to qualify. DOE has recommended 18°C; these regulations are under review and discussion.

Table V.12

SUMMARY: GEOTHERMAL LOAN GUARANTY APPLICATIONS*

CATEGORY	NUMBER	AMOUNT ($M)
I. Applications Received		
A. Approved	4	$43.4
B. Under Evaluation	4	$104.2
II. Applications Currently Being Prepared	8	$429.9 (Estimated)
TOTAL:	20	$577.5 (Estimated)

*Figures are current as of February 1980.

Table V.13

STATUS OF GEOTHERMAL LOAN GUARANTIES MADE TO DATE*

BORROWER	LENDER	GUARANTY	PROJECT	LOCATION	RESULTS
Republic Geothermal, Inc.	Bank of America	$ 9,017,000	Resource exploration and testing	East Mesa, California	Drilled 4 reinjection and 7 production wells. Temperature 160-168° C at wellhead when pumped. USGS agrees that project can produce 64 MW for 25 years.
Westmorland Geothermal Associates	Bank of America	$29,100,000	Resource exploration, testing, and full field development	Westmorland, Imperial County, California	Guaranty recently awarded: exploration beginning.
Geothermal Food Processors, Inc.	Georgia State State Teachers Retirement System	$ 3,500,000	Process heat to dry agricultural products	Brady Hot Springs, Nevada	Plant operational and running at 88-100% of capacity. Drying contracts sufficient to repay debt. Back-up well flow affecting production well.
CU-I	Bank of Montreal (California)	$ 1,800,000	Resource exploration and testing	Brawley, Imperial County, California	One production well drilled to 14,000 feet, wellhead temperature of 232°C. salinity of over 269,000 ppm.

*Figures are current as of February 1980.

Table V.14

LOAN GUARANTY PROJECTS UNDER EVALUATION*

PROJECT	TYPE	$ millions COST	GUARANTY
1. CU-I South Brawley, Cal.	Electric - Field Development	$ 78.8	$ 49.4
2. NCPA, The Geysers	Power Plant	$ 56.2	$ 47.1
3. Oregon Trail Mushrooms Vale, Ore.	Mushroom Plant	$ 6.2	$ 4.7
4. R&R Energies, Inc. Cove Fort, Utah	Ethanol Plant	$ 4.0	$ 3.0

*Figures are current as of February 1980

Table V.15

LOAN GUARANTY APPLICATIONS BEING PREPARED*

APPLICATION	LOCATION	AMOUNT
1. 25 MWe Power Plant	Puna, Hawaii	$ 50.0 Million
2. 55 MWe Power Plant	Roosevelt Hot Springs, Utah	$ 16.0 Million
3. Field Development	The Geysers, Cal.	$ 18.7 Million
4. 50 MWe Power Plant	Heber, Cal.	$ 50.0 Million
5. Gasohol Projects	Various locations	$ 38.9 Million
6. Ethanol Projects	Various locations	$ 19.4 Million
7. Agricultural Project	Brady Hot Springs, Nev.	$ 1.5 Million
8. 2 District Heat Projects	Various locations	$ 1.2 Million
9. Field Development	East Mesa, Cal.	$ 66.0 Million
10. 64 MWe Power Plant	East Mesa, Cal.	$ 87.0 Million
11. Field Development and 66 MWe Power Plant	The Geysers, Cal.	$ 48.7 Million
12. Sulphur Processing Plant	Cove Fort, Utah	$ 4.0 Million
13. Field Development and Power Plant	Coso, Cal.	$ 28.5 Million
	TOTAL	$429.9 Million (Estimated)

*Figures are current as of February 1980.

L GEOTHERMAL LOAN GUARANTY PROGRAM

On January 5, 1979, DOE published its proposed regulations for GLGP for comment from interested parties. (44FR 1568.) The proposed regulations incorporated GLGP amendments in P.L. 95-238, which in summary:

- Pledge the full faith and credit of the United States to the payment of these guarantees
- Allow DOE to borrow funds from the Department of the Treasury, if balances in the Geothermal Resources Development Fund are insufficient to carry out guaranty and other responsibilities
- Authorize DOE to help the borrower pay the loan principal
- Allow DOE to complete and operate a plant acquired through default
- Limit loans to $100 million per project and to $200 million per qualified borrower
- Clarify the scope of direct heat projects
- Limit to 1 percent the guaranty fee to be imposed annually on the outstanding guaranteed debt, and permit fee collection to be deposited in the Geothermal Resources Development Fund
- Authorize DOE to reimburse qualified public agencies and Indian tribes for a portion of the interest when a holder of the debt guaranteed under this regulation is required to include that income under Chapter 1 of the Internal Revenue Code
- Authorize certain forms of community impact for loans over $50 million.

In response to the request for comment, DOE received 12 replies, many of which were accepted. In addition, DOE's staff review of the proposed regulations produced a number of changes.

In July, several amendments to PL 93-410 were proposed by DOE and Senators Church and McClure. These amendments would increase the amounts of DOE's guaranty on loans to small businesses, municipalities and cooperatives; establish a time limit on DOE's processing of loan guaranty applications; and clarify certain provisions and authorities contained in PL 95-238.

In FY 79, four loans were approved:

- o Republic Geothermal, Inc., obtained a guaranty of $9 million from the Bank of America for resource

exploration and testing in East Mesa, California. Four reinjection and seven production wells were drilled. Temperatures of 160°C were obtained at the wellhead. It is estimated that 64 MW can be produced from this project for 25 years. Republic plans to submit guaranty applications for follow-on loans for full field development and power plant construction within the near future.

- Westmorland Geothermal Associates was awarded $29.1 million by Bank of America to explore, test, and develop the resource in Westmorland (Imperial County, California). This guaranty was approved June 22; a site for drilling has not yet been chosen. Among the issues to be resolved are whether a viable resource can be found, whether a power plant can be built at acceptable terms, and whether Westmorland can find a customer.

- Geothermal Food Processor, Inc., borrowed $3.5 million from the Georgia State Teachers Retirement System, with Bankers Trust as the trustee under a refinancing of the original $2.8 million note with Nevada National Bank ($200,000 remains in an escrow account). Geothermal heat is being used in a food-drying project at Brady Hot Springs, Nevada. The plant, now operating at 88-100 percent of capacity, has netted drying contracts sufficient to repay its debt. It has successfully completed its first full season of operation. Additional food processing contracts are being sought to enhance plant utilization.

- California-Utah (CU1) borrowed $1.8 million from the Bank of Montreal (California) for resource exploration and testing in Brawley (Imperial County, California). One production well was drilled to 14,000 feet with a wellhead temperature of 232°C and a salinity of over 269,000 ppm. Whether the technology exists to permit use of such a highly saline resource, and whether handling costs will be deemed reasonable, remains to be determined. Meanwhile, DOE's San Francisco office is evaluating a loan guaranty application for a follow-on contract for full field development, in the amount of $49.4 million.

Tables V.12 through V.15 summarize the status of all loan guaranty applications.

J. PLANNING

Facilitated by its Budget and Planning Working Group, the principal planning efforts of IGCC in 1979 were to establish a National Progress Monitor, a computerized Project Management System, a coordinated interagency budget, and lease planning.

The Department of Energy has the lead in establishing the National Progress Monitor, a system for collecting information about geothermal activities directly from state and Federal agencies, state geothermal teams, and research institutes. The information will be sent to a national center where it will be collated and published in periodic progress reports. The first report was scheduled for publication early in FY 80. The IGCC's Annual Report to Congress will be based in large part on the Monitor's files

The Project Management System, when fully implemented, will analyze national plans and programs by examining the impact of each geothermal project on each site. Power-on-line schedules will be developed for each site, to check and balance national goals and to provide a basis for determining the nature and level of activity for Federal agencies.

An integrated budget of all Federal agencies involved in geothermal development was prepared and forwarded to OMB early in the development of the FY 81 budget. This document allows each agency to compare its program levels and to anticipate work loads due to other agency's activities.

For lease planning, the Department of Energy has lead responsibility for establishing geothermal production goals on Federal lands. Using these goals, the Bureau of Land Management, USGS, and the Forest Service will develop a leasing schedule that can meet these goals. A report on the production goals and a coordination meeting are scheduled for FY 80.

The Budget and Planning Working Group will continue to take the lead in national geothermal planning.

In addition to the national level planning, state level planning was accomplished in cooperation with state governments. Fifteen states, mostly in the western United States received planning contracts or grants. State fact books that described the resources and status of geothermal development in the state were prepared and general plans for the state were developed. In some states more detailed plans were developed for selected areas and for specific sites. The site specific plans include identification of principal decision in the development process and a development schedule.

Economic Studies

Economic studies provide basic information to determine the potential for geothermal energy compared with other energy sources. They also provide information to guide the geothermal program. Two studies updated resource availability curves, showing that significant amounts of geothermal energy for electricity or direct use are available at costs competitive with conventional sources.

A study was completed on the decision process for geothermal field developers. Results showed that large energy firms are not interested in reservoirs with small capacity because the potential profits are too small. Small firms, on the other hand, are only interested in small projects where large amounts of equity are not at risk. Thus, the commercialization program has to be very diversified to meet the needs of the different types of developers.

A study of market potential was completed for some of the western states. In these studies, each demand center (city or town) within a reasonable distance of a geothermal resource was analyzed to determine the amount of energy demand that could be supplied by geothermal energy at a cost competitive with conventional sources. In 60 cities geothermal district heating would provide lower cost heat than conventional sources.

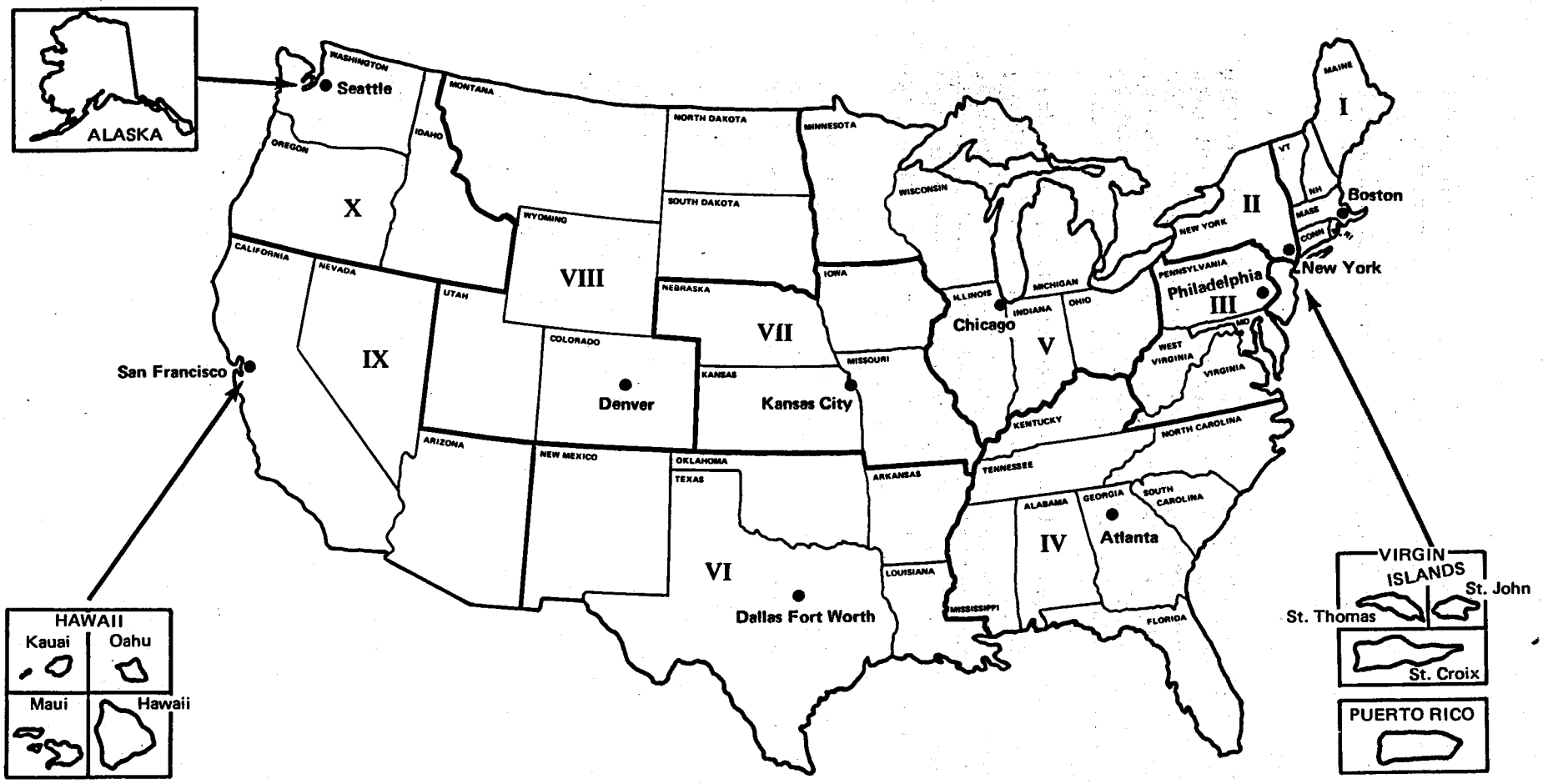
The economic studies were used to locate those industries that are expected to grow significantly over the next two decades and that could use geothermal energy. These will be the industries most likely to build new plants near geothermal resources to obtain an economical and reliable energy supply, and will form the key targets for development planning teams.

According to net energy calculations for all geothermal energy forms, i.e., hydrothermal, geopressured, and hot dry rock, the useful energy obtained greatly exceeds the useful energy expended.

A study of the potential for geothermal energy as a supply of economically competitive electricity for the aluminum industry revealed that at current aluminum prices, transmission of electricity from one of the most promising sites (Roosevelt Hot Springs) to existing aluminum plants in the Northwest was economically competitive. Additional sites and the location of new plants at geothermal sites would be economically feasible only if aluminum prices increase.

Simple cost accounting models were developed for electric and direct heat use to allow rapid analysis of proposed economic incentives, and many of the economic incentives proposed for geothermal energy legislation were analyzed.

Ten Standard Federal Regions



Region	States
1	Conn, Maine, Mass, NH, RI, Vt
2	NJ, NY, Puerto Rico, Virgin Islands
3	Del, DC, Md, Pa, Va, W Va
4	Ala, Fla, Ga, Ky, Miss, NC, SC, Tenn
5	Ill, Ind, Mich, Minn, Ohio, Wis
6	Ark, La, NM, Okla, Tex
7	Iowa, Kan, Mo, Neb
8	Colo, Mont, ND, SD, Utah, Wyo
9	Ariz, Calif, Guam, Hawaii, Nev, Trust Territory of the Pacific Islands
10	Alaska, Idaho, Ore, Wash